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POWER

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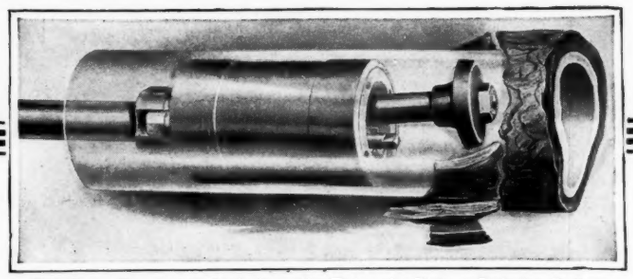

The Dean Removing Scale from the Tube of a Return Tubular Boiler

Taking The Initiative

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Dean Boiler Tube Cleaner

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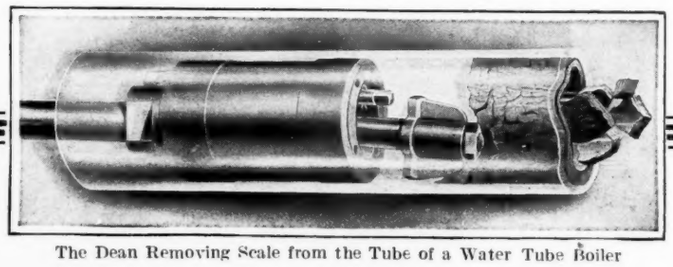

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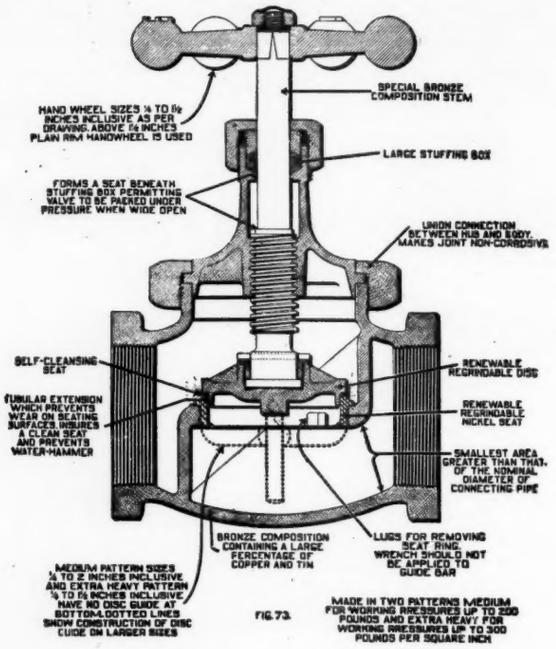
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FIG. 73.
MADE IN TWO PATTERNS MEDIUM FOR WORKING PRESSURES UP TO 200 POUNDS AND EXTRA HEAVY FOR WORKING PRESSURES UP TO 300 POUNDS PER SQUARE INCH

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can justly be called a valve of perfection, as it embraces all of the above necessary features, and more too, as the seating faces can be reground many times, without removing the valve from its connecting box pipe, before it is necessary to renew the seat and disc.

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Other features that aid in maintaining the high reputation of the valve, are,—a non-corrosive union connection between the hub and body, permitting the valve to be easily taken apart or assembled; a ***renewable seat*** made of a ***hard*** and ***close-grained nickel,*** having great durability,—and a stuffing-that can be packed under pressure when the valve is wide open.

Lunkenheimer "Renewo" Globe, Angle and Cross Valves are made in sizes ranging from ¼ to 3 inches inclusive, and in two patterns,—Medium, for working pressures up to 200 pounds, and Extra Heavy, for pressures up to 300 pounds.

Specify and insist upon securing genuine ***"Lunkenheimer make."*** Do not accept substitutes,—they are never as good as the genuine.

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Dearborn Treatment is never a source of expense; every dollar spent for Dearborn Treatment yields a profit.

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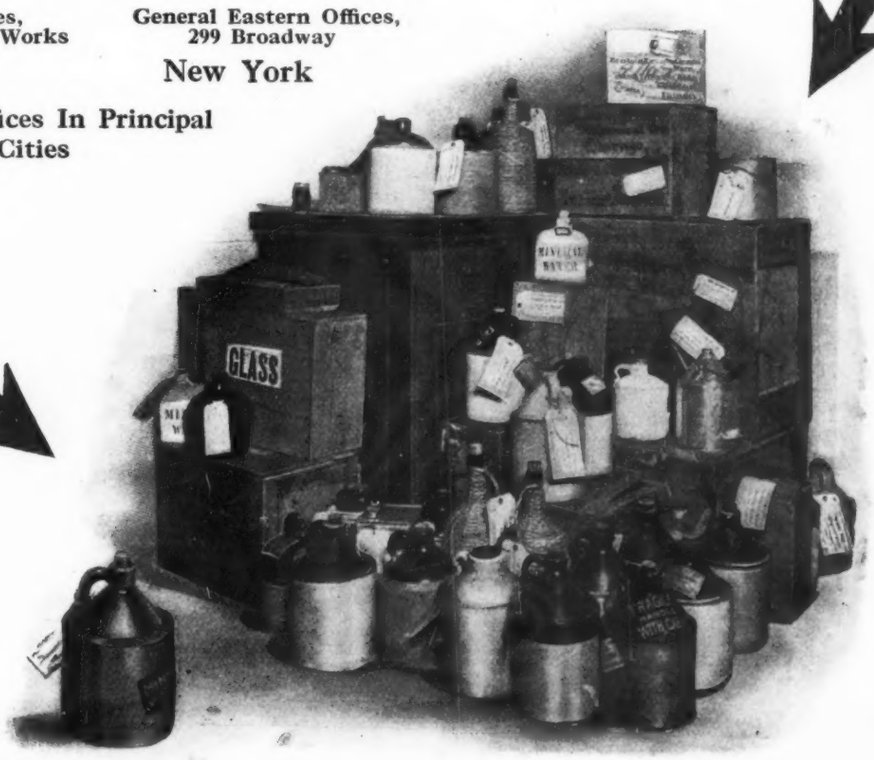

No. 2

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POWER

Vol. 35 NEW YORK, FEBRUARY 6, 1912 No. 6

EVER hear a man say, "I have so much work to do, I don't know where to begin"? If you have, you may have noticed that he stood around doing nothing all the time he was complaining instead of being busy doing some of his work. Several chances to one the man wasn't lazy. Probably he simply lacked system.

Ever hear a man say, "I haven't any time to read"? Without a doubt, that man has not been systematized.

When a man chronically "has too much to do," "has no time," "is too busy" to do this or attend to that, there is something the matter. And usually the trouble lies with the man himself.

There are some cases where a "job" actually is too big for one man, but they are rare. In the common or garden variety of overwork the trouble is simply that the "victim" is not living up to his capacity.

He needs a mental self over-hauling.

Probably his condition is due to gradual and natural growth in his duties on the one hand and lack of sufficient growth or improvement in his methods, on the other.

The one thing needful in such a case is to take about a half day off and carefully think out a "system" for putting his efforts to the best use. It is astonishing how much one can accomplish if a little time is spent in planning out the work ahead.

In some cases the thing to do is to delegate unimportant or routine work to a capable assistant. Too many men fritter away valuable time on work that might just as well be done by an understudy.

Wonderful things have been accomplished in certain manufacturing establishments by studying conditions and factors and then laying out the work both of the apparatus and the operatives so that each could work to best advantage. In many cases the results have been advantageous to both the employer and the employee.

This is called efficiency engineering.

Now, efficiency engineering can be applied to the individual and his work just as well as to an entire establishment. Boiled down and shorn of all its frills and refinements, efficiency engineering means simply the use of common sense.

Bear in mind that time is money. In justice to yourself don't squander it upon tasks that are not worth the price. First, get a rational point of view of the worth of your time; then, lay out a plan for spending it to the best advantage; and finally, stick to it!

Various Types of Steam Meters

By Prof. G. F. Gebhardt

General classification of steam flow meters and description of the principal types.

In the present article, those meters are considered which fall in the velocity class; those in the throttling class will be treated in a second installment.

The weight of fluid flowing through an opening at any instant may be calculated by the equation

$$W = A\,y\,V \qquad (1)$$

in which

W = Weight in pounds per second;
A = Cross-sectional area in square feet;
y = Density of the fluid in pounds per cubic foot;
V = Velocity of flow in feet per second.

All steam meters for indicating or recording the weight of steam flowing through a pipe are based upon the law expressed in equation (1). Thus, for steam of constant density the opening through which it flows may be made constant and the variation in velocity will be an indication of the rate of discharge; or the velocity may be held constant and a variation in the amount of opening will be an indication of the weight discharged.

Unfortunately, the density of steam is seldom constant for any appreciable length of time under commercial conditions of operation, and herein lies the inherent defect of all steam meters which depend for their operation upon a variation in the area of efflux or a variation in velocity. The density of steam is a function of its pressure and quality and any variation in either will affect the weight of discharge as determined from equation (1). Pressure variation may be automatically compensated for, but corrections for quality must be made in each specific case.

The different means adopted for transmitting this area and velocity variation to the indicating or recording devices overlap to such an extent as to render a classification of steam meters very unsatisfactory. The chart is offered as a guide in grouping the most commonly known devices.

Shunt	Velocity	Pitot tube	Impeller	Lindenheim 1896)* Gebhardt (1908)†
			Water manometer	Burnham (1906)† Clyde (1910)†
			Mercury manometer	General Electric (1910)*†
		Current	Impeller	Holly (1877)*
Series	Throttling	Floating valve	Mechanical control	St. Johns (1893)†‡ Gehre (1896)†‡ Baeyer (1902)†‡ Bendemen (1902)†‡ Sargent (1908)† Lindmark†‡
		Stationary disk	Mercury manometer	Gehre-Hailwachs (1907–1910)*†‡ Sarco (1910)*†‡ Storrer (1910)†‡
		Venturi tube	Bourdon manometer	Eckardts (1903) †‡
			Mercury manometer	Parenty (1886)†‡ Builders' Iron Foundry (1910)†‡

*Integrating. †Indicating. ‡Autographic.

From this chart it will be seen that all meters may be grouped into two general classes, which, for want of more suitable names, may be designated as shunt meters and series meters. Owing to lack of space only those of the former class will be described in this article, and those of the latter class will be taken up in a succeeding article. The series meter is an integral part of the piping and the entire mass of fluid to be measured passes through the apparatus. It is not portable and cannot be readily applied to pipes of different sizes. In the shunt meter only a small portion of the fluid to be measured is diverted through the apparatus, and the pipe line need not be disconnected for its installation. One instrument suitably calibrated may answer for any size of pipe.

Both series and shunt meters may be grouped into two classes, depending, first, upon whether the natural velocity existing in the conduit is used to operate the indicating mechanism or, second, whether an artificial pressure drop affords the means of actuating the mechanism. The first type may be classified as "velocity" meters and the latter as "throttling" meters.

Velocity meters may be subdivided into two groups: those in which the current of steam impinges directly against the vane of an impeller and those in which the pressure due to velocity actuates the indicating or recording mechanism.

Holly Steam Meter

One of the earliest steam meters recorded was constructed in 1877 by Birdsill Holly, a section through which is shown in Fig. 1. The upper impeller is placed in the path of the steam and its speed of rotation is a measure of the weight of steam flowing. The lower impeller is submerged with a view of decreasing the speed of the rotor. The results were never satisfactory as the inertia of the rotating members caused the vanes to run ahead or lag behind the stream and the windage and eddy losses were variable.

Lindenheim Steam Meter

The Lindenheim meter, Fig. 2, is a marked improvement over the Holly in that it compensates for pressure variation and does not require the entire mass of fluid to flow through the apparatus. It consists of an impeller inclosed in a steam-tight casing attached to the main pipe as indicated. The rotation of the impeller is transmitted to the counter through the agency of a variable speed cone, C, the position of which is shifted by a steam-actuated diaphragm, and this movement is transmitted to the cone, thus compensating for the pressure change. This instrument, like the Holly, was never a commercial success on account of friction of the stuffing-boxes and gearing and the losses due to windage of the impeller and eddies.

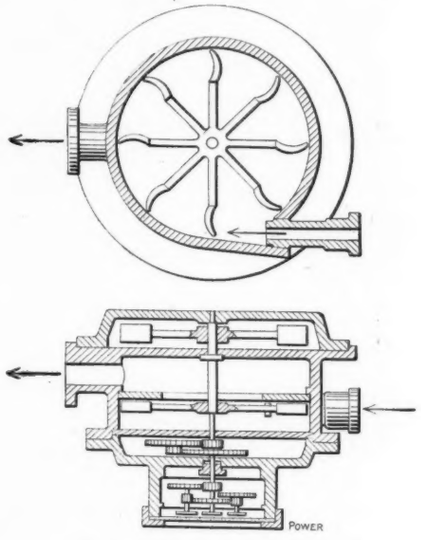


FIG. 1. HOLLY STEAM METER

Gebhardt Steam Meter

During the past few years the writer has constructed a number of velocity meters which have overcome some of the defects of the Lindenheim device. Referring to Fig. 3, a thin, smooth aluminum

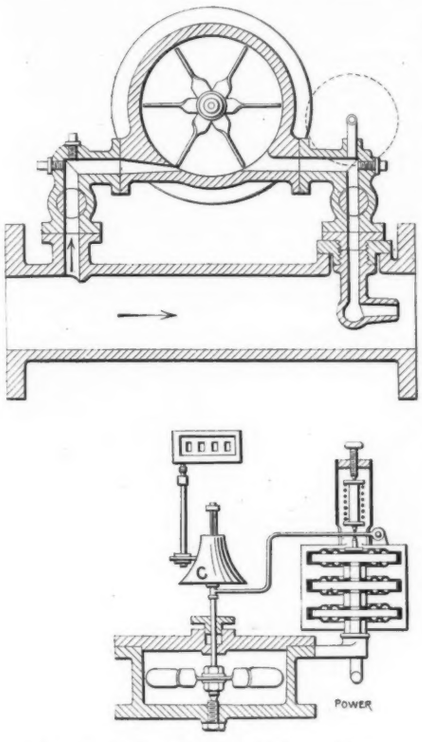


Fig. 2. Lindenheim Steam Meter

ring *A*, with a permanent steel magnet *N* (inlaid as indicated), is supported on pivot bearings within a steam-tight casing *O*. A small jet of steam impinges upon the periphery of the disk and effects rotation. The motion of the disk is imparted by the magnet *N* to magnet *N'*, outside the casing. By this construction windage and eddy losses have been appreciably lowered, inertia has been gradually reduced and stuffing-box friction has been entirely eliminated. Tests of these instruments when new gave results agreeing within 10 per cent. of condenser measurements for continuous flow and for velocities between 25 and 50 ft. per second, but the error increased with the higher velocities. Difficulty with the bearings rendered them inoperative after a few days' trial on account of the extremely high speed of rotation. No attempt was made to automatically compensate for changes in pressure or quality of the steam.

Fig. 4 shows a modification of the instrument just described, in that the wheel does not revolve but is constrained to move through the arc of a circle by the spiral spring *G*. The device is purely indicating. The impulse of the stream increases with the velocity and deflects the wheel *A* through a greater angle, the degree of deflection being a measure of the weight flowing through the main pipe. By means of suitably calibrated charts the instrument may be made to give fairly consistent results for a uniform flow and constant pressure and quality of steam. For intermittent flow the results are extremely erratic.

In point of compactness, simplicity, ease of application and the integrating feature of the mechanism, the impeller type of velocity meter fulfills the requirements of the ideal meter, but it is probable that its inherent limitations will prevent it from ever becoming a commercially successful instrument.

Burnham Steam Meter

The Pitot tube is the basis for the operation of a number of commercially successful steam meters of the velocity type. Fig. 5 shows a section through a Burnham meter, illustrating one of the simplest methods yet devised for indicating the rate of flow through a pipe. *A* and *C* are two ordinary gage-cocks and *G* is a common gage-glass; *C* being connected with the static nozzle *S*, and *A* with the dynamic tube *D*. The height of water *H* is proportional to the square of the velocity of steam flowing through pipe *P* and automatically adjusts itself to the variations in velocity; thus, for decreasing velocities, the water in glass *G* discharges through *D* until the water column *H* balances the velocity pressure in pipe *P*, and for increasing velocities, condensation from the upper part of the instrument accumulates and the water column *H* rises until a balance is effected for the higher velocities.

This simple device in connection with a calibrated scale gives readings within 5 per cent. of condenser measurements for continuous flow and constant pressure and quality of steam (for velocity pressures corresponding to 1½ in. of water or more). For a considerable variation in pressure and quality or for marked changes in the rate of flow, the instrument is not reliable. Its sensitiveness is greater at high velocities since the height of the water column in the gage-glass increases with the square of the velocity of the steam in the main pipe. For interrupted flow, as when connected to a high-speed engine, the water column may be made to closely approximate the mean velocity by suitably throttling the gage-cocks.

Fig. 6 shows an application of the same principle with only one connection to the main pipe.

The limitations of the instrument just described which materially affect the accuracy at low velocities are due, first, to fluctuation in the height of the water at the end of tube *D*, due to surface tension; second, to variations in the density of the water column in the gage-glass *G;* third, to capillarity in the gage-glass *G;* fourth, to a sudden increase in velocity, tending to "blow out" the water column, and, fifth, to eddies in pipe *P*. Notwithstanding these limitations the instrument is sufficiently accurate for many purposes when a purely indicating device is desired.

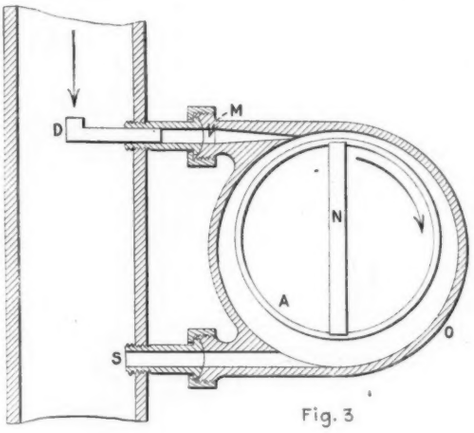


Fig. 3

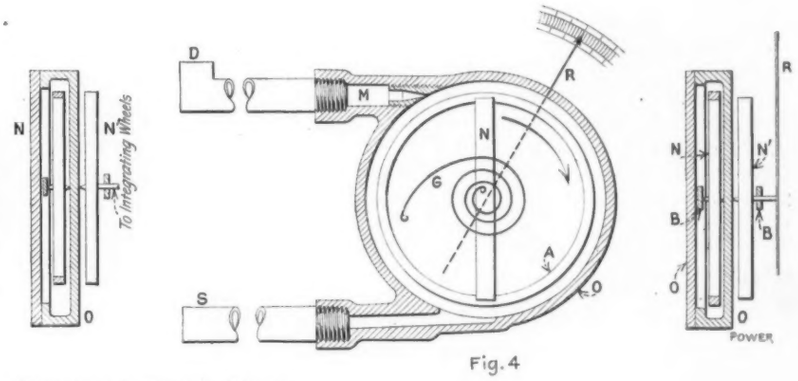


Fig. 4

Gebhardt's Steam Meter

Fig. 7 shows a modification of the Burnham meter in which the defects of the single gage-glass device are eliminated. The error due to the variation in water level at the end of the dynamic nozzle is entirely dispensed with by making the tube a "dry" tube; that is, water of condensation is not returned through

the dynamic nozzle. The temperature of the water in the gage-glass is practically constant, all condensation from the static end being discharged through the drain *F* to the chamber below, and all water carried over by the dynamic end being discharged into pipe *P* directly to the overflow *G*. The area and volume of the chamber *M* are so large compared with those of the glass *W* that sudden variations in flow do not materially affect the level of water in *M* and cannot blow the water out of *W*. The only defect in the instrument is the error due to capillarity in the glass *W*, which amounts to but 0.05 in. for a ¾-in. tube.

The operation is as follows: Velocity pressure is transmitted through tube *D* and opening *O*, into the body of the chamber *M*. This pressure, acting on the surface of the condensed water in the chamber, forces the water into the glass *W* until a balance is effected. Condensation is discharged continuously through pipe *P* and the water seal *U* of the main pipe. Tests of this meter have given results agreeing within 2 per cent. of the condenser measurements for continuous flow for all velocities ranging from the equivalent of a 1-in. to a 10-in. water column. No provision is made for automatic correction of the pressure and quality variation.

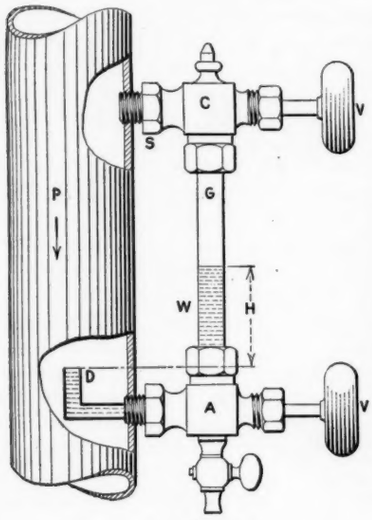


Fig. 5

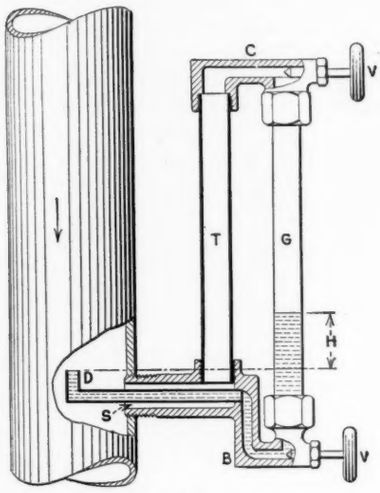


Fig. 6

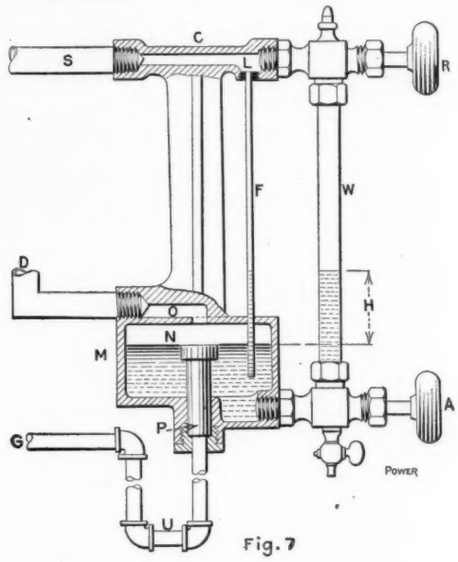


Fig. 7

FORMS OF BURNHAM STEAM METER

CLYDE STEAM METER

Fig. 8 shows a commercial form of the Burnham meter as constructed by the Clyde Machine Works, of Chicago. It differs from the one described in Fig. 6 only by the addition of the tube *A*, the function of which is to insure static pressure in chamber *C*. The chart is graduated for a considerable range in pressure and quality. It is a purely indicating device and readings must be taken frequently to obtain average results.

The relation between the height of the water column and the velocity of the steam in the main pipe at the entrance to the dynamic tube in the Burnham type of meter may be determined from the well known equation

$$V = c\sqrt{2gh} \qquad (2)$$

in which

V = Maximum velocity of flow in feet per second;

c = Coefficient determined by experiment;

g = Acceleration due to gravity = 32.2;

H = Height of a column of steam equal in weight to the water column H.

This equation may be expressed as

$$V = K\sqrt{h - \frac{dw}{ds}} \qquad (3)$$

in which

K = Coefficient determined by experiment;

h = Height of water column in inches;

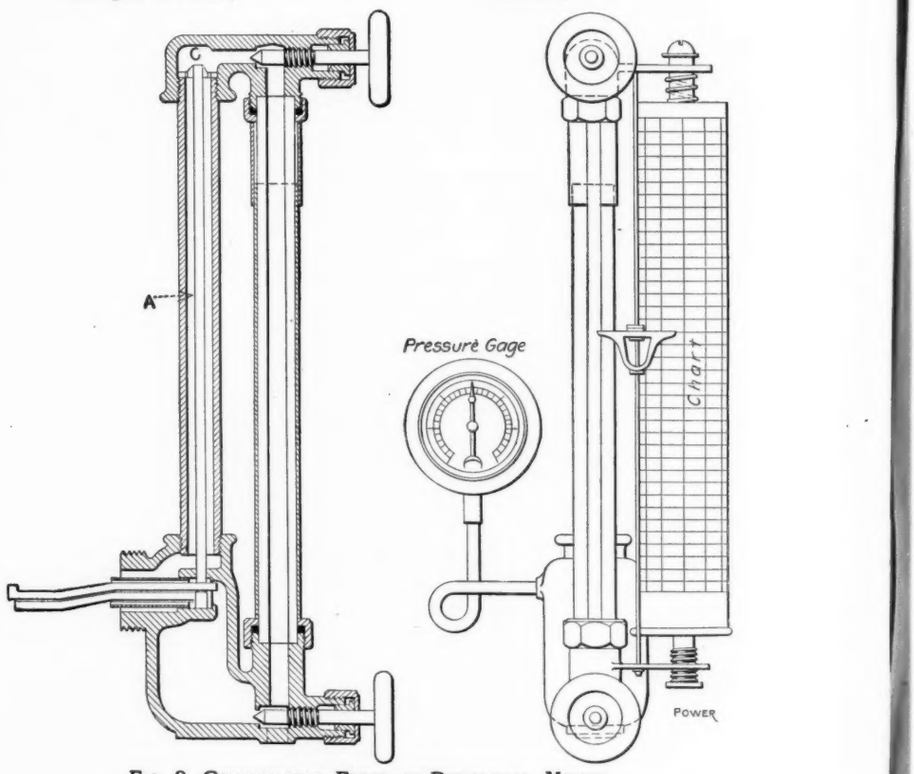


FIG. 8. COMMERCIAL FORM OF BURNHAM METER

dw = Density of water in gage-glass in pounds per cubic foot;

ds = Density of steam in the main pipe.

By combining equations (1) and (2)

the weight of steam flowing is readily calculated. (See *Transactions*, A. S. M. E., Vol. 31, p. 603.)

General Electric Steam Meter

The General Electric Co. has recently placed on the market a number of steam meters of the Pitot-tube type in which a mercury column is used to measure the velocity pressure. The principle involved is an old one, but this company is the first to exploit it successfully from a commercial standpoint. Three styles are manufactured, (1) type I, form D, in which the velocity pressure is measured directly by means of a U-tube manometer; (2) type I, form F, in which the variation in the height of the mercury is transmitted to an indicating dial through the agency of floats and pulleys, and (3) type R, form D, in which the variation in the weight of the mercury column actuates a recording mechanism by means of a series of compound levers.

The principle of the simple indicating device is illustrated in Fig. 9, in which *S* is the static nozzle at right angles to and *D* the dynamic nozzle facing the current; *U* is an ordinary U-tube manometer partially filled with mercury. When there is no flow the surface of the mercury in the columns *N* and *W* will be on the same level and the upper portions will be filled with condensed vapor. When there is a flow, the mercury will be depressed as indicated and the difference *H* in the heights of the mercury columns will be a measure of the velocity of flow at the point in the pipe where the dynamic tube is placed.

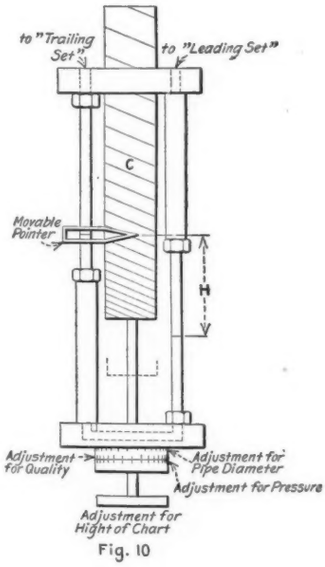


Fig. 10

This velocity may be expressed by substituting the proper values in equation (2), thus

$$V = K\sqrt{h - \frac{dm}{ds}} \qquad (4)$$

in which

dm = Density of the mercury in pounds per cubic foot (other notations as in equation (3).

A comparison of equations (3) and (4) will show that the mercury manometer is less sensitive than the water manometer by an amount equivalent to $\sqrt{\frac{dm}{dw}}$ or approximately 3.7. The variable height of the water column above the mercury is usually included in the value of the coefficient *K*.

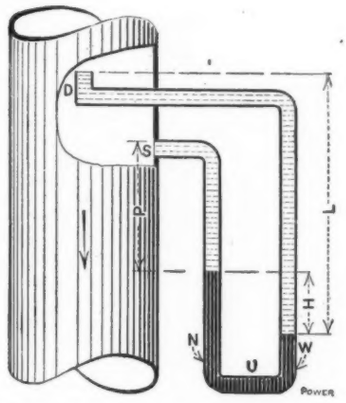


Fig. 9. Pitot Tube with Mercury Manometer

The General Electric indicating flow meter, shown in Fig. 10, differs from the simple device just described in that a simple nozzle plug, shown in detail in Fig. 11, is used in place of the ordinary static and dynamic nozzles. Referring to Fig. 11, *TT* are the static openings, or "trailing set," and *LL* the dynamic openings or "leading set." The plug is screwed into the pipe with the "leading set" directly facing the current and the connections to the manometer are made through the openings *T'* and *L'*. The weight of steam flowing may be obtained directly from the height of the mercury column *H*, Fig. 10, by means of suitable charts based upon experiments. Adjustment for variations in pressure, quality and pipe diameter are made by setting the chart cylinder *C* in accordance with the graduated scales at the bottom of the instrument.

For general purposes a single revolving chart is furnished, the readings of which, multiplied by the area of the pipe, give the weight of steam flowing. For low velocities the difference in the heights of the mercury columns, if vertical, is so small as to lead to serious error; hence provision is made for this by inclining the manometer as indicated in Fig. 12. With this the actual head of mercury due to the velocity is *H*, but the difference in the lengths of the columns is *D*. The indication on the chart corresponding to the height of the mercury in the glass *T''*, multiplied by a constant depending upon the inclination of the chart, is the rate of flow in pounds per hour per square inch of the pipe cross-section.

The accuracy of this meter depends entirely upon the refinement of adjustment and the extent of error in reading the height of the mercury column. If correctly set, an error in reading of $\frac{1}{16}$ in. for a velocity corresponding to a vertical column ½ in. high would be 12½ per cent., whereas the same error referred to a vertical column 6¼ in. high would be but 1 per cent. Tests of this instrument, conducted at the Armour Institute of Technology, gave readings for continuous flow agreeing within 1 to 8 per cent. of condenser measurements, depending upon the rate of flow. For interrupted flow the departure from condenser readings was more marked. This meter is portable, simple in construction and readily applied to any pipe by inserting the nozzle plug at the required point, although considerable care is necessary in setting it up and in making the necessary adjustments for pipe diameter, steam pressure and quality.

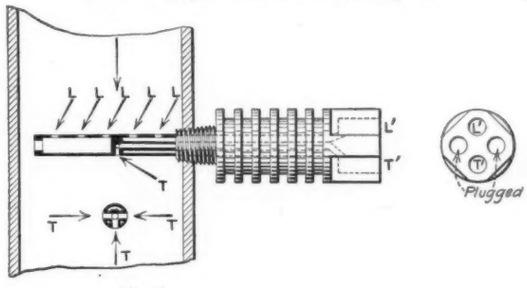


Fig. 11

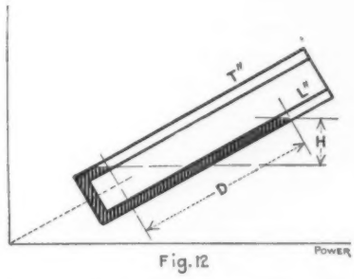
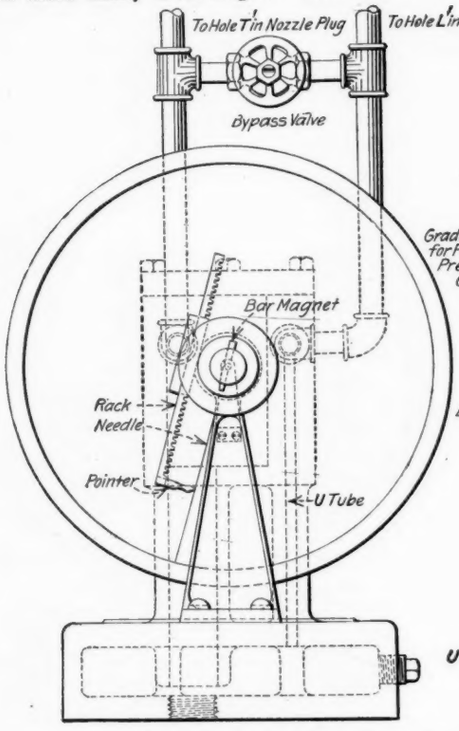


Fig. 12

General Electric Indicating Flow Type Meter, Nozzle Plug and Inclined Mercury Manometer

Fig. 13 gives the general details of the type I, form F, indicating flow meter. It differs from the one just described in that the variation in height of the mercury column is transmitted through a float and pulleys to two bar magnets, one within the casing and the other without. The indicating needle is fastened to the outer magnet and revolves in harmony with the variation in height of the mercury column. A movable rack fitted with a pointer, and operated by graduated cylinders for pipe-diameter,

pressure and quality adjustments, indicates the portion of the circular chart from which the needle readings are to be taken; these adjustments must be made by hand. This instrument is fully as accurate as the one previously described, but it is much more delicate and is more easily disarranged. Connection



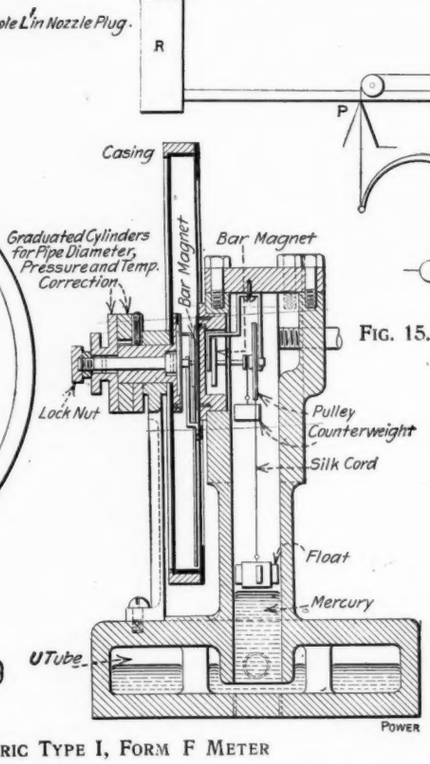


FIG. 13. GENERAL ELECTRIC TYPE I, FORM F METER

is made with the main steam pipe by nozzle plugs which are interchangeable with either instrument.

The autographic instrument, Fig. 14, is finding much favor with engineers and is being rapidly adopted by the large power plants. Its operation is shown diagrammatically in Fig. 15. Two cylindrical mercury cups, *R* and *R'*, constituting the legs of a U-tube mercury manometer are pivoted on a knife-edge *P*, and are connected to the nozzle plug by the flexible tubes *A* and *A'*. The instrument may be placed at any point below the level of the nozzle plug, one instrument being sufficient for a number of nozzles. When there is no flow the mercury in the two wells is at the same level and the system is in perfect balance. When there is a flow the velocity pressure causes the mercury to flow from *R* to *R'* and the latter is lowered, carrying with it the recording pin *C*. The vertical distance on the chart between *O* and *C* is a measure of the weight of steam flowing. (This system of mercury wells was used as early as 1886 in a steam meter designed by Parenty.

Pressure variation is automatically compensated for by the sliding weight *W*, the position of which relative to the knife-edge is effected by the Bourdon tube *G*; thus for increasing pressures the gage tube tends to straighten out and lower the weight, thereby increasing the leverage of the well *R'*. Adjustment for quality is made by shifting the position of the weight *W* by hand. Thirty of these meters are in use at the Argo power plant of the Corn Products Refining Co.

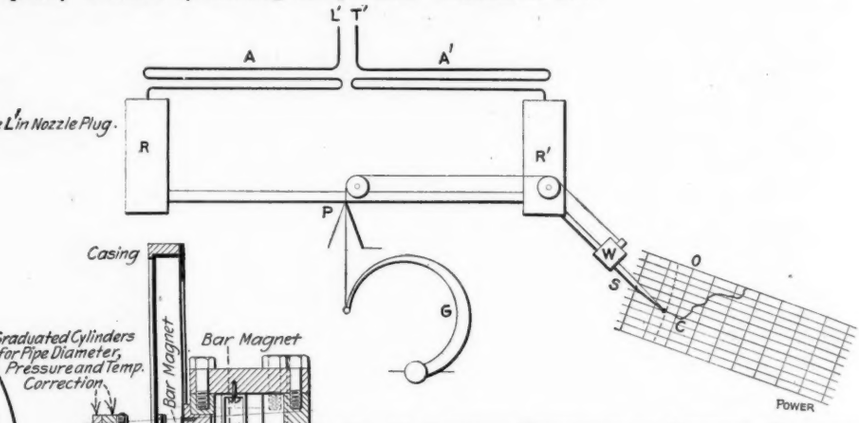


FIG. 15. SHOWING PRINCIPLES OF GENERAL ELECTRIC RECORDING STEAM GAGE

and, according to tests made by the engineering staff, are accurate within 2 per cent. of condenser measurements for continuous flow.

The writer's experience with this style of meter has been very satisfactory for continuous flow, but the results were not consistent for interrupted flow when connected with a reciprocating pump or engine, the chief objection being that the charts must be integrated in order to ascertain the total flow for any given period of time. The ordinates on the chart are not directly proportional to the weight of steam flowing; hence the diagram cannot be integrated in the usual manner with an ordinary planimeter. The General Electric Co. furnishes a planimeter which is designed to compensate for the variation in the value of the vertical coördinates so that the average flow per unit of time can be determined.

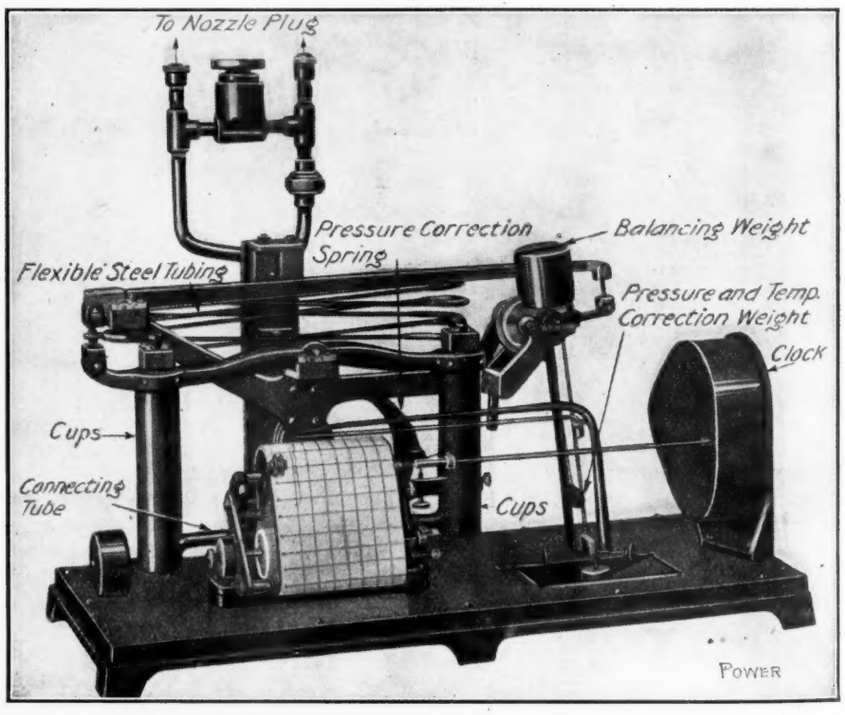


FIG. 14. GENERAL ELECTRIC RECORDING STEAM METER

Oil Burning with Different Settings

Results of a series of tests carried out on a horizontal return-tubular boiler to determine the relative economy of different furnaces and the effect of variation in the draft when burning oil.

A recent bulletin of the Lousiana State University and A. & M. College contains the results of some interesting tests made by Prof. Kerr and H. A. Nadler, of that university, upon different types of oil-burning furnaces. The tests were conducted upon a 6x18-ft. horizontal return-tubular boiler at the Smithfield sugar factory during the past sugar-drying season. The draft was supplied by a single stack which served a battery of three boilers, one of which was used in making the tests. With the exception of the last two, all the tests were made with a Higgins burner.

Setting No. 1

Reference to Fig. 1 will show that the setting was arranged so that the air for combustion could be supplied to the under side of the grate through a long duct from the back end of the boiler setting. This duct, behind the bridge-wall, was covered over with brick loosely thrown in, the object being to preheat the air before it reached the burner. The end of this duct was arranged so that the amount of opening could be controlled or closed. In this setting the draft-doors were tightly closed by means of brick and mortar. The fire-doors were closed in the same manner, excepting for two openings of about 2½x4½ in. each, which were used as peep-holes, but which, when the boiler was in operation, were entirely closed by the insertion of bricks. Thus the entire front of the furnace was closed, all the air admitted coming from the rear of the setting through the brick duct. The air thus delivered to the under side of the grate was admitted to the furnace above through an opening 4 in. wide between the front of the grate and the front of the furnace wall, the grate, with this exception, being solid. The grate-bars were covered with two layers of firebrick laid flat. In this way there was no possibility of air flowing into the furnace except through the 4-in. opening at the front. On this flat surface bricks were thrown in loose so as to give a gradual slope from near the front of the grate up to the top of the bridge-wall. With the tests made on this setting, as with all the others, the draft was regulated by means of a damper in the flue leading to the stack.

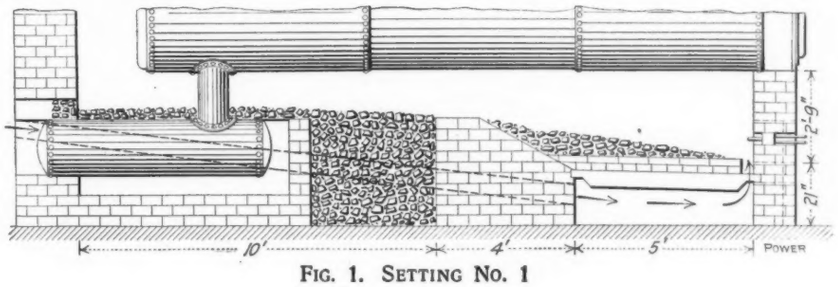


Fig. 1. Setting No. 1

Reference to tests Nos. 1 to 8 inclusive, in the accompanying table, shows that the lowest economy (No. 7) occurred with the damper wide open and with only 75.3 per cent. of the rated load. The next lowest economy occurred in test No. 3, with normal load and the damper closed until the draft in the flue was reduced to .092 in. On the other hand, the best economy was that shown in test No. 5 where there was a slight overload and medium draft. In tests Nos. 3 and 6 where the evaporation was low, the damper was closed so far as to fill the setting with smoky, rolling flames, although no smoke appeared from the top of the stack.

The fact most clearly shown by these tests is that the economy is reduced by too high or too low draft, depending upon the load.

Setting No. 2

The most common method is to admit all of the air in oil burning at the front of the furnace in such a manner that the air enters in currents practically parallel to the current of fuel issuing from the burner. As the atomization and gasification of the fuel are incomplete immediately after its issue from the burner, it would seem that admission of air toward the back end of the furnace should be advantageous, especially if it could be injected across the current of gases so as to facilitate mixture of gases and air. With this in view, setting No. 2, as shown in Fig. 2, was arranged so as to admit air through the furnace floor just in front of the bridge-wall. For this purpose all of the loose brick was removed, leaving the grate covered with a smooth, flat layer of firebrick although just in front of the bridge-wall these bricks were left sufficiently far apart to provide seven ½x8-in. holes. The 4-in. opening between the ashpit and the furnace was provided as in setting No. 1, so that air entered at this place as well as through the grate at the back. In other respects, the setting was the same as No. 1, the air being preheated by its passage from the rear of the setting. Upon starting the burner with the arrangement just described it was found that too much air entered at the bridge-wall and that the flames were directed by the bridge-wall against one spot on the bottom of the boiler shell. To remedy this the holes in the grate at the back were gradually closed during the preliminary runs until the only air which entered at this point leaked past bricks which were laid flat over the holes. The result was that the quantity of air entering at this point was comparatively small, though the flames were still thrown almost perpendicularly

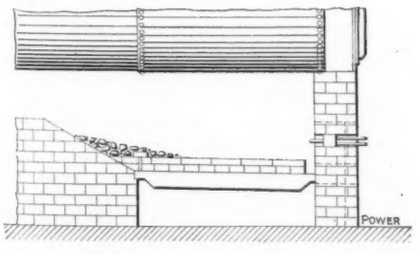


Fig. 2. Setting No. 2

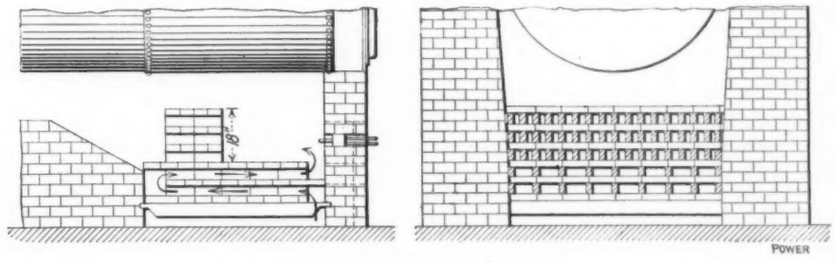


Fig. 3. Setting No. 3

against the boiler shell. This latter was remedied by throwing in a small quantity of loose brick.

However, on account of the difficulty of securing a satisfactory distribution of the flame throughout the setting and the heating surface, only one test was made.

Setting No. 3

In this setting arrangement was made for preheating the air by passing it back and forth through firebrick passages directly under the furnace (see Fig. 3). The grate-bars were lowered almost to the floor of the ashpit and a network of brick was built up by placing one upon another without any mortar so as to give the desired path to the gases as indicated.

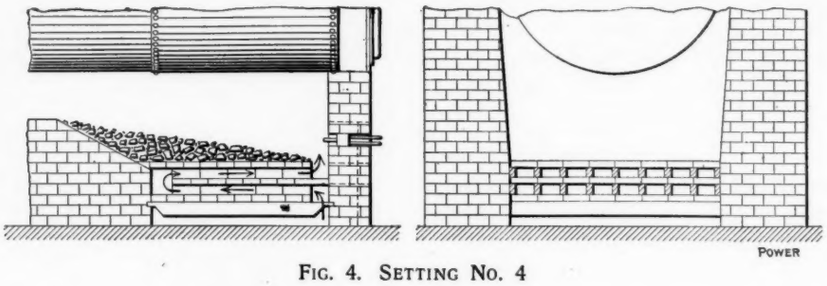


Fig. 4. Setting No. 4

In order to diffuse the fuel and mix the air and the gases, a checkerwork wall was built above the floor of the furnace. The air ducts from the rear of the setting were closed and all the air entered through an opening of practically 1 sq.ft. in the ashpit door.

Test No. 10 was thrown out on account of an error in the feed-water measurement. Owing to conditions at the factory it was impossible to carry the full load while running with this setting. Hence, as underloading reduces the efficiency, it may be assumed that the evaporation per pound of oil would have been better for this setting under normal load. Notwithstanding this, the results compare very favorably with those in setting No. 1.

Setting No. 4

In this setting, shown in Fig. 4, the checkerwork used for diffusing the gases in setting No. 3 was replaced by loose bricks thrown in so as to slope gradually from near the front of the grate to the top of the bridge-wall. As with setting No. 3, the air was preheated by its passage back and forth under the furnace, all air being admitted from the front.

Test No. 14, with this setting, was made with an air supply adjusted in the light of former tests, to give the best possible results. The lower evaporation per pound of oil, 14.88, was, therefore, somewhat unexpected, especially in view of the favorable conditions as regards load and excess air. Test No. 15, however, under practically the same conditions, gave an evaporation of 15.38 lb. It should be noted that the boiler tubes were blown out just prior to this last test, which, no doubt, accounts in part for the increased efficiency.

Setting No. 5

This setting, shown in Fig. 5, is the same as setting No. 4 as far as that part of the furnace in front of the bridge-wall is concerned. In all the previous settings, however, that part of the combustion space back of the bridge-wall was filled with firebrick to the level of the top of the bridge-wall. With the idea of investigating the value of this space for combustion, the loose bricks were removed to a depth of about 15 in., although the brickwork around the mud-drum prevented this enlargement all the way back. With the idea also that some air admitted back of the bridge-wall would aid in better combustion, a 4-in. pipe with a number of 1-in. holes in it was inserted through a hole in the side wall of the furnace just back of the bridge-wall. The holes were located so that the air entering would be divided upward at right angles to the current of gases. As in the previous settings, the air entering at the grate came from the front of the furnace, although the opening in the ashpit door was nearly closed.

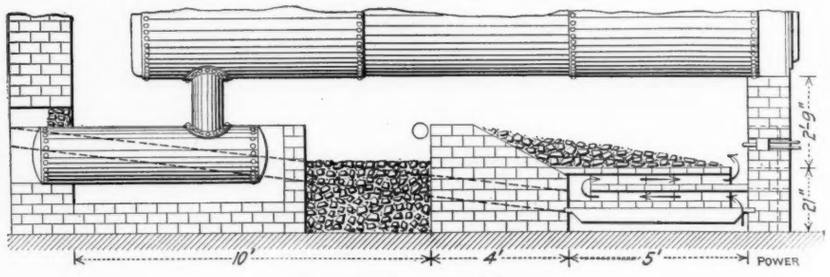


Fig. 5. Setting No. 5

Aside from tests 22 and 23, which were made with burners of a size insufficient to carry the load, the lowest evaporation was that in test 17. In this test the damper was closed to such a point that the furnace was filled with a rolling flame, a condition accompanied by a low efficiency in the other settings. Test 19 was thrown out on account of leakage in the feed-water line. The damper was closed too much in test 16, although not quite so much as in 17. The remaining tests showed very good results. It will be noted that the excess air was lower in these tests than in most of the others, which may be due to the admission of air through the pipe at the rear of the bridge-wall and to the enlargement of the combustion space back of the bridge-wall.

Conclusions

The tests showed that the amount of steam used in atomizing depends largely upon the operation of the burner, a white flame being usually accompanied by a small consumption of steam for atomizing and a transparent red or orange flame by a large quantity of steam. The average percentage of steam used for atomizing (about 4.38) shows fairly good work, although it is not by any means the best, as 2.5 to 3 per cent. can be obtained under the proper conditions. Further inspection of this column shows that the percentage of steam used for this purpose decreases with the load.

The increase in economy due to proper draft regulation is plainly shown by the results of the tests, although certain variable conditions, such as load, made the results due to changing the draft less regular than they otherwise would have been. The relation between draft and load is shown by the curves in Fig.

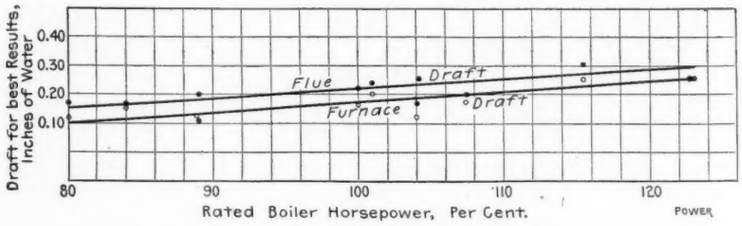


Fig. 6. Effect of Draft on Horsepower

6. In this it will be noted that the average distance between the curves for furnace draft and flue draft represents about .04 in. of water. This difference represents the friction of the gases in the boiler tubes and passages. It might have been expected that this difference would have been greater as the load increased, due to increased volume, and therefore a greater velocity of the gases. However, in general, there was less excess air at the greater loads.

With the flue damper wide open, the flame in the furnace moved at a high velocity with a tendency to break up and disappear at or near the bridge-wall, the color being rather light. Upon gradually closing the flue damper the velocity of the flame could be seen to decrease, the flame extending farther and farther toward the rear of the setting and becoming denser and redder. By continuing the gradual closing of the damper a point was reached where the velocity of the flame was very low and the flame would roll, and the furnace setting would be entirely filled with a dense and generally smoky-looking flame, this without smoke at the top of the stack. The tests showed that this latter appearance is an indication of a condition very near that which gives the best efficiency and that by setting the damper at a position just short of this rolling action of the flame the best effec. is obtained.

Since the best boiler efficiency is dependent not only upon proper air supply but also upon proper loading, it is best, as far as possible, to take care of the variations in load with as few boilers as possible. In other words, instead of slightly reducing the fuel supply to all of the burners when the load is reduced, it is better to make the reduction with one or two boilers and not change the others.

World's Coal Production

The following figures show, according to the United States Geological Survey, the coal production of the principal countries of the world in 1910, except those for which only 1909 figures are available:

United States	501,596,378
Great Britain	296,007,699
Germany	245,043,120
Austria-Hungary (1909)	54,573,788
France	42,516,232
Belgium	26,374,986
Russia and Finland	24,967,095
Japan (1909)	16,505,418
Canada	12,796,512
China (1909)	13,227,600
India (1909)	13,294,528
New South Wales (1909)	7,862,264
Spain (1909)	4,546,713
Transvaal	4,446,477
Natal	2,572,012
New Zealand (1909)	2,140,597
Mexico (1909)	1,432,990
Holland (1909)	1,235,515
Queensland and Victoria	1,119,708
Italy (1909)	611,857
Sweden (1909)	272,056
Cape Colony (1909)	103,519
Tasmania (1909)	93,845
Other countries	5,236,903
Total	1,278,577,812
Percentage of the United States	39.2

PRINCIPAL RESULTS FROM TESTS WITH DIFFERENT SETTINGS

Test Number	Conditions of Test	Steam Pressure, Gage	Flue Temperature Deg.	Draft in Flue, Inches of Water	Draft in Furnace, Inches of Water	Per Cent. of Rated H.P. Developed	Evaporation from and at 212 deg. per Lb. of Oil	Steam for Atomizing, Per Cent. of Total	Excess Air, Per Cent.	Efficiency of Boiler, Per Cent.	Efficiency of Boiler and Furnace, Per Cent.
	SETTING NO. 1										
1	Steady load; no smoke	74	403	0.117	0.089	81.5	14.35	2.89	107	71.6	69.5
2	Heavy long flame; damper wide open; ashpit doors closed; air from back of setting	81	402	0.224	0.164	102	15.41	5.98	97.5	76.6	72.3
3	Smoky rolling flame; no smoke from stack, air from back of setting; steam valve on burner wide open	70.9	449	0.092	0.102	99.1	14.06	6.15	65.9	70.3	65.2
4	Long heavy rolling flame; damper wide open; air supply from rear, high velocity of gases	76.2	466	0.320	0.251	117.6	15.32	3.85	124	76.3	73.5
5	Whitish yellow flame at front ending with blue at rear. Draft less than in No. 4; steady load; as little steam as possible used in burner	88.2	454	0.175	0.132	106	16.1	6.28	.....	80.1	75.2
6	Fire rolling and completely filling combustion chamber	88.4	463	0.162	0.132	110	14.41	4.44	53.8	71.8	68.7
7	Air ducts from rear closed; air supply from opening in ashpit door; short white flame; damper wide open	88.5	461	0.282	0.227	75.3	13.2	5.19	184.8	65.6	67.5
8	Conditions similar to No. 7, with damper opening slightly changed	85.3	476	0.11	0.11	89.3	15.75	5.25	69.1	78.4	74.4
Average		81.56	446	0.185	0.151	97.6	14.83	5.06	96.7	73.8	70.8
	SETTING NO. 2										
9		81	483	0.147	0.126	99	14.46	4.85	64.8	72.1	68.5
	SETTING NO. 3										
11	Medium draft, clear fire, flame slightly blue and ending just back of bridge-wall	80.7	489	0.235	0.149	86.2	14.45	6.57	121.2	72.1	67.2
12	Draft less than No. 11 and short, transparent flame	85.3	476	0.171	0.12	80	15.56	5.89	114.8	77.5	73.0
13	Boiler washed out previous to this test	81.9	460	0.20	0.13	89	15.26	5.0	106.2	76	77.2
Average		82.6	475	0.20	0.13	85.1	15.09	5.82	114.1	75.2	70.8
	SETTING NO. 4										
14	Transparent white flame ending just back of bridge-wall; firebrick very hot	84.3	462	0.175	0.158	104	14.88	3.67	89.3	74.25	71.5
15	Tubes blown just before starting test; flame white and opaque; draft higher than in No. 14	86.75	462	0.222	0.202	103	15.38	5.26	89.3	76.6	72.7
Average		85.52	462	0.187	0.180	103.5	15.13	4.46	89.3	75.42	72.1
	SETTING NO. 5										
16	During first hour, clear bluish rolling flame; later, shorter flame due to increased air supply	86.8	417	0.159	0.135	84	15.18	4.41	65	75.6	72.4
17	Load steady; damper closed; heavy bluish flame at front, clear at back	86.9	454	0.184	0.162	109.5	14.70	2.25	37	73.2	71.5
18	Same as No. 17 except more draft; steam valve wide open	80.8	479	0.253	0.228	123	15.56	3.2	55.5	77.7	75.0
20	Long white opaque flame; damper such that further closure would cause flame to enter tubes	88.8	456	0.197	0.170	109.5	16.05	2.37	75.5	80.0	78.2
21	Heavy draft	85.5	472	0.345	0.262	106.2	15.31	3.21	88	76.4	74.0
Average		82.1	456	0.227	0.235	106.4	15.35	3.09	70.2	76.6	74.2
22	Von Phul burner used at full capacity; white flame	83.1	432	0.210	0.181	89.8	14.05	3.00	108.5	70.2	68.0
23	Home-made burner	84.7	419	0.175	0.145	89.4	14.22	3.19	.....	71.0	68.8

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

Tom Hunter continues his narrative on hoisting engines and tells why overwinding accidents occur.

He explains a device which he made to prevent confusion of signals and so avoid accidents.

Thanksgiving morning dawned cold and dull, and the air was occasionally filled with flurries of snow from off the mountains which surrounded the town. I saw but little of Hunter during the day, but after the six-o'clock dinner we selected comfortable seats and after lighting our cigars, he said:

"I am at a loss just what to say or where to begin. So much has happened during my career that, taking it all in all, it would require a good many evenings to tell of my experiences."

"Tell me of the most thrilling you have had," I suggested, as I leaned back in my seat.

A Thrilling Experience

"The most thrilling experience, I think, was the one I mentioned last night. It occurred years ago, when I was a young man, and the lives at stake were those of a dozen miners who were being hoisted to the surface after their day's work was done. By chance, it was on a Thanksgiving eve, and possibly the thoughts of the holiday caused me to allow my mind to wander to other things besides my work.

"I had been hoisting coal from the bottom level when I got the signal to stop at the second level, which was down about three hundred feet, while the lower level was a trifle over a thousand feet deep. A hoisting engineer is most likely to make a mistake when, having worked at one level, he changes the drum and hoists from another. He gets in the habit of gaging the time it will take the car to run up and does not watch the indicator as closely as he should.

"The engine room was built with a window in the wall just back of the double drum so that it was possible to see the shaft head, and this undoubtedly saved the lives of those men. I got the signal to change from the bottom level to the second and then came the signal to hoist. It was then that I forgot that men were on the cage instead of coal and that I had changed to the upper level. I opened the throttle wide and the cage came up at a terrific speed. I did not realize that it was near the top until I saw it flash past the window. The men were transfixed with horror and were clinging to each other in a frenzy of fear. One or two were on the bottom of the cage having been weakened by their inability to breathe, owing to the speed at which the car traveled.

"It is curious how fast one can think at such a time. I saw in that moment the hoist demolished, the cage smashed into a tangled mass, the rope part and the mangled men and wrecked cage dropped back into the mine a thousand feet below. This was followed by a vision of a dozen funerals, weeping women and fatherless children, and after that myself surrounded by a howling mob of avenging men who would be satisfied only with my life."

"Horrible!" I exclaimed at the vivid picture he had drawn.

"Horrible? It was worse than the tortures of hell! While these thoughts were flashing through my mind, I realized that there was a chance to save them. A hoisting engineer as a general practice does not use the band brake to stop his engine, but depends upon plugging it, or reversing, to use a more proper term. That was my chance! I brought the reversing lever over with a jerk, and although I hardly expected to accomplish my purpose in time, the engine came to a stop and began its reverse motion. After the cage had dropped a few feet I held the car suspended and, making for the door, securely fastened it on the inside. After the men had time to collect themselves, I lowered the cage to the ground level."

"Why did you keep the men on the cage instead of bringing them to the surface?" I asked.

"That was a matter of self protection, as the men in their frightened, frenzied state would have made a rush to the engine room, and had they gained admittance they would have made a short end of 'yours truly.' After they had a chance to cool down a little, although they made a demonstration, they finally went away and that ended the matter, for I resigned my position, knowing that it would hardly be safe to continue at that hoist."

"I see," I replied; "that was certainly a close call."

"It was one chance in a thousand that I was enabled to stop the cage in time, and this was only because the hoist differed from most others; that is, the cars of coal were hoisted about sixty feet above the ground level and were then run upon a trestle and into the breaker. Had the cars been run off at the ground level, as is the case with many hoists, those men would have been killed, for there would have been no time to stop before the car hit the top of the hoist. I dislike to think of it even now.

"When I settled down in a new place, where no one knew me, I decided to devise some kind of a scheme which would make it next to impossible to make a mistake."

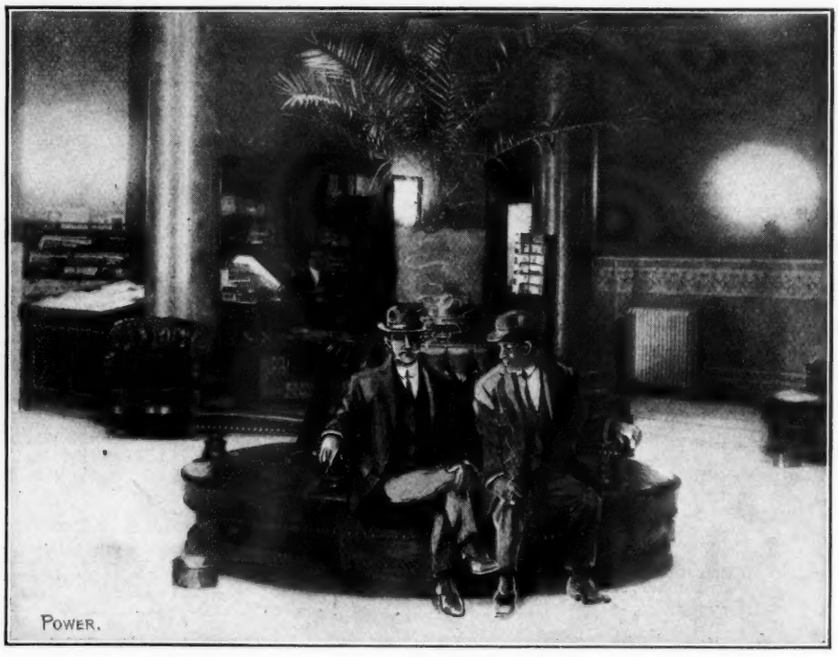


Fig. 1. We Selected Seats and Lighted Our Cigars

"Do engineers make many such mistakes?" I asked.

Overwinding

"It is not uncommon to hear of an engineer overwinding. It is generally done, however, by his forgetting to reverse the engine and, after the car has been run from off the cage, to start up and hoist the cage and the car through the top of the head. I knew of one engineer who did that three times in as many years, but he was an exception."

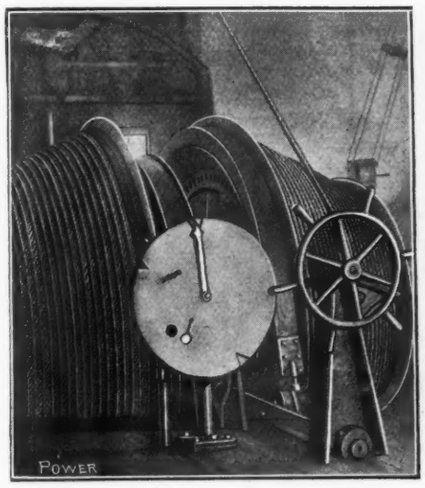


Fig. 2. Indicator Disk without Shield

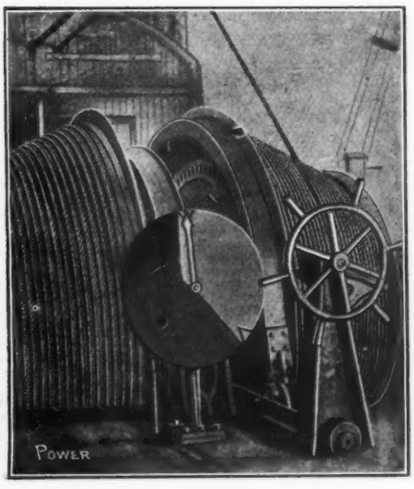


Fig. 3. Indicator Disk with Shield

"How did you arrange your safety device?" I next inquired.

"As you doubtless know, the telltale dial of a hoisting engine is put in a convenient place where the engineer can easily see it while stationed at his levers. In my case it was set almost in front of the two drums, and quite low.

"It is customary to mark the levels on the face of the dials with chalk, and in this instance the mark for the 220-foot level came at a point about one-third of the circumference of the dial, the surface level or head mark being at the top, at which position the indicator finger pointed when the cage was at the surface with the car ready to be pushed off by the headman.

"I made a false cover of sheet iron to place over the disk, so that when I was hosting from the 220-foot level there were but two marks on the dial to watch and there could be no confusion of level marks. When I had to hoist from the lower level the false cover was removed, and then of course there were three marks visible on the disk, but no attention was given to the center mark. The cover fitted loosely over the disk and was easily lifted from its position when it was necessary to change it. It was arranged as shown in these photographs." So saying, he handed me the photographs shown in Figs. 2 and 3.

"You will notice that the cover has a handle attached to assist in putting it in place."

"Quite an idea," said I, much interested.

Telltale Signal

"Oh, that was but part of the arrangement. On the face of the dial I had a small disk of flat sheet iron painted white and attached to an arm, which was operated by an arrangement attached to the rear of the large dial. While the cage was at any point between levels, this small white disk hung down, but as soon as the compressed-air signal was given the air pressure forced the arm and the disk up to an angle of perhaps 15 deg. and covered a bright red circle I had painted on the face of the telltale dial. Unless this red mark was covered by the white disk I knew that the signal to hoist had not been given and of course I would not start to hoist."

"That seems all right," I said, "but what good would the white disk do when you had the cover on the telltale?"

"It worked just the same," was the reply. "At a point just opposite the red disk I had cut a hole of the same diameter so that while hoisting the red showed through and, when the signal had been given to hoist, the white disk would come up and cover the red spot and show white, or the safe starting point. With this arrangement there could be no mistake about hoisting if one but used his eyes."

"That seems a pretty good idea, but how does that white signal disk operate?"

"I can best illustrate that by a sketch," answered Hunter, and he proceeded to make a drawing similar to that shown in Fig. 4. "You see, the shaft which I will designate as *A* has mounted upon it the disk and arm *B*, a weight pulley *C* from which a weight is hung by means of a cord, and a ratchet wheel *D*. This latter member has an arm attached to it by means of screws and it is connected to the piston of the air cylinder *E* by a piston rod.

"Just beyond the ratchet gear *D*, I made a frame on which a pawl was pivoted at *F* and fitted with a pin *G*. Then on the shaft of the indicator I put an eccentric *H* which would, when in a certain position, throw a movable shipper arm, to which was secured the projecting piece *K*. This piece was notched at the top so that when the eccentric was not bearing against the end of the shipper *J*, the pawl *L* would engage with the teeth in the ratchet wheel. The member *J* slid on the pin *M* and ran up on the pin *N* when the arm *J* was moved toward the right or away from the cam shaft, and as the outer end was lifted the extension piece *K* engaged the pin *G* and lifted the pawl so that it would not engage with the ratchet wheel *D*, and if the disk *B* was in the safe or hoisting position the weight *O* would then rotate the shaft *A* toward the lift, thus bringing the disk to a lower position ready to be thrown into the safe or working position again."

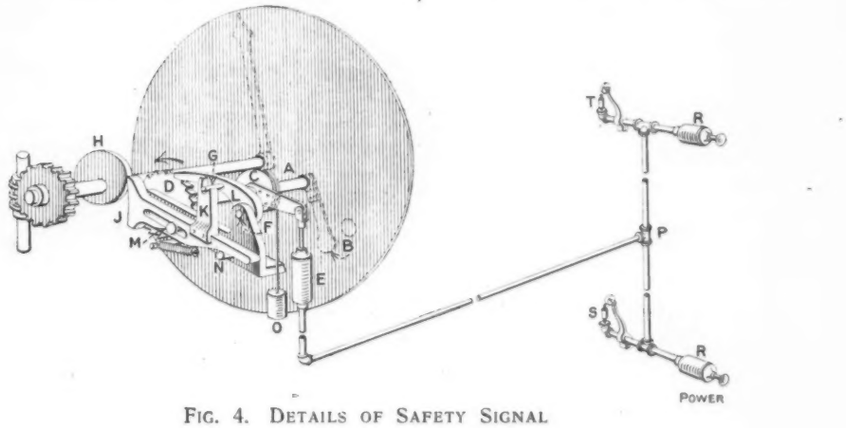


Fig. 4. Details of Safety Signal

"It had to be timed accurately, I should judge," I said.

"Yes, but that was easily done; it all centered upon the position of the eccentric *H*."

"I hardly see how air operated the

device," I remarked, not quite grasping the exact principle of operation.

"The piping arrangement was similar to that shown at *P*," explained Hunter as he sketched in the pipe line. "The arrangement operated like a charm.

"When the headmen above have removed the loaded car and pushed an empty car on the cage a bell is rung; when the foot man at the level from which coal is being hoisted has run off the empty car and put a loaded car on the cage he pushes the air plunger *R*, which operates the plunger at *S*, one in the engine room at *T* and the plunger in the cylinder *E*. The first two plungers rang a bell but the plunger *E* rotated the ratchet *D* in the direction of the arrow. This movement threw the white disk *B* to a position covering the red mark on the face of the indicator dial, which indicated that it was safe to start. When the engine was started the cam *H* came around and moved the shipper *J* toward the right, which lifted the pa l *L* and the weight *O* swung the disk *B* away from the red danger signal."

"That was quite an ingenious arrangement," I said as I studied the drawing, "and it must have been quite a help."

Just then the bell-boy began calling, "Mr. Hunter," and, excusing himself, my friend went to answer a telephone call, and I went to my room to dream of wrecked hoisting apparatus and safety devices, while a dozen or more headless, legless miners danced about my bed.

A Glimpse at a Sugar Mill Boiler Plant

By Fred H. Colvin

During a recent visit there were indications of a big crop of cane and of sugar in Cuba, some claiming a record crop, others being content to call it good. In any case, all the sugar mills were being overhauled, many of them being considerably enlarged, in preparation for the grinding season which began along in December. For, once the cane was ready, the grinding must go on day and night for four or five months, or until finished.

In a general way, the power plant of a sugar mill may be compared to that of a rolling mill. The engine is connected to the train of grinding rolls in much the same way as in a rolling mill, and the amount of power required is very heavy. The cane is first fed between the breaking rolls, which have deep corrugations and look like many pairs of herringbone gears on a single shaft. The finishing rolls are plain and are set very closely together. They squeeze the cane so dry that it drops on a conveyer and goes direct to the furnaces to be burned.

At the Providencia Sugar Mills, which I visited, the machinery was a strong mixture of American, British, French and German, the engines being built in Glasgow while the electrical apparatus, such as the motors on the centrifugal separators, was mostly American.

Leaving the last pair of rolls, the dry cane or bagasse drops on a large conveyer and with a few changes reaches the top of the boilers in the conveying belt *A*, as can be seen in Fig. 1. A chute *B* is provided for each pair of boilers, going down between them and feeding two furnaces. The furnaces are approximately 7 feet wide by 9 feet long, the grates covering nearly the whole surface of the furnace. The grate is about one-half air space, the bars and openings being about 1 inch each in width.

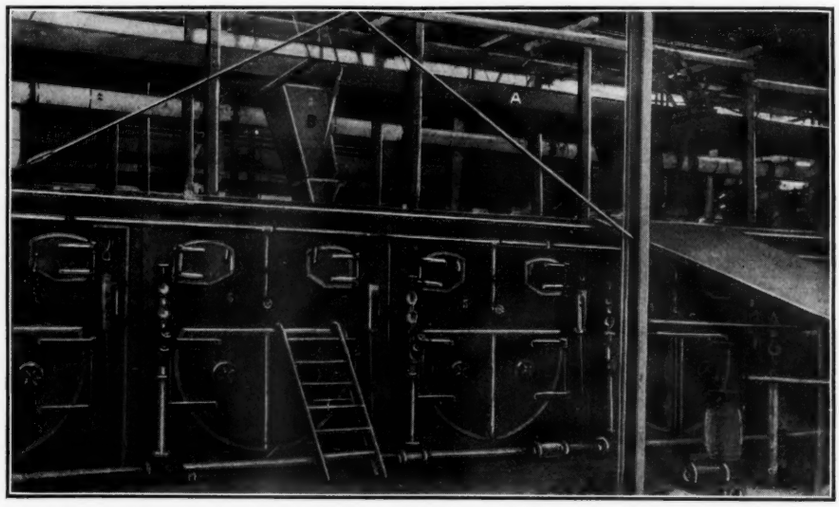


Fig. 1. Boiler Fronts, Showing Method of Feeding Bogasse

With the exception of starting the furnaces at the beginning of the season, bagasse furnishes the entire fuel supply at this mill, and this is said to be general in Cuba where economical engines, generally of the Corliss type, are used. In Louisiana the cane is less woody and steam economy is very important as the bagasse does not supply over two-thirds of the fuel. The furnaces are started with wood. Forced draft is used, two blowers being provided, one at each end of the battery of 10 boilers, so that either or both can be used as necessity demands. A little idea of the furnaces, ashpits and blower connections can be had from Fig. 2. The ashes are raked out from beneath and wheeled away by hand. They are rather fine and are used as a fertilizer on the lands of the plantation.

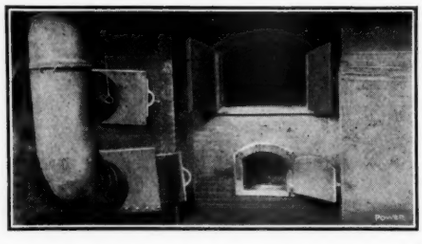


Fig. 2. Blower Connections

As few of the men on native Cuban or Spanish plantations speak English, and as nothing much below the position of chief engineer is at all financially attractive to an American, the field in Cuba for the readers of Power is decidedly limited.

There is nothing to fear in the climate, which many Americans find delightful in most ways, but sanitary conditions, schools and society on a sugar plantation leave much to be desired for those who are accustomed to towns or cities, the nearest comparison being a large ranch in the West, with the odds in favor of the West.

Smelter Fumes Abatement

E. G. Cottrell, of San Francisco, an expert in the employ of the Federal Bureau of Mines investigating the smelter fumes problem, announced at the convention of the American Chemical Society that he and several Californians associated with him had turned over their patent rights in a device for the suppression of this nuisance to the Smithsonian Institution and that the gift had been accepted.

Mr. Cottrell began his investigations into the problem of smoke from smelters several years ago while a professor at the University of California. He soon reached the point where his device should be put in operation at a large plant and a number of others connected with the university joined with Mr. Cottrell in the undertaking, as it required considerable money. The apparatus has been installed at a number of plants and has been so successful that it is believed the smelter fume nuisance will soon be abated.

The royalties will be used to aid other investigators to bring their ideas to practical accomplishment.

A New Type of Fluid Motor

If a pair of spiral or herringbone gears are held together as in Fig. 1, there will be found to be a lozenge-shaped pocket in the center, as at *a* in Fig. 2. If the gear is revolved, this space is extended, and as the teeth inclosing it advance to the respective positions, the volume will be increased to that shown at *bcde* and *f*.

A fluid under pressure admitted to the space *a* and acting upon the receding surfaces would drive the gears, the energy produced being equal to the product of the pressure and the volume generated. If the driving fluid were by throttling; inclosed forms of both types of governors being furnished.

With a given mean effective pressure the capacity of an engine is proportional to the volume which it generates; that is, to its piston displacement. As this displacement is the product of the piston area and speed, or of the factors *LAN* in the common formula,

$$Hp. = \frac{PLAN}{33{,}000}$$

we may write

$$D = LAN$$

and

$$Hp. = \frac{P}{33{,}000} \times D$$

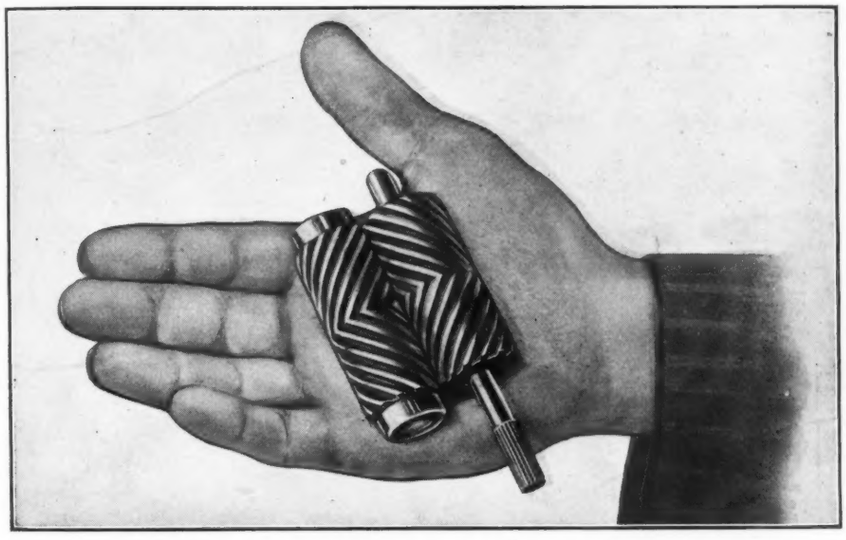


FIG. 1. THE ROTOR OF THE SPIRO MOTOR

expansible and were cut off at any point, it would expand into the increasing volume, and the advantages and economies of expansion be realized just as in a cut-off engine working with a regular piston. When the ends of the grooves in which the action occurs pass the line of contact so that they are no longer closed by the teeth of the opposite gear, the fluid would be exhausted, as indicated at the end of the gear in Fig. 2.

It is upon this principle that the "Spiro," a new type of motor invented by John H. Van Deventer, superintendent of the Buffalo Forge Co., acts. The operating fluid is admitted through ports *pp*, Fig. 2, and one of the claims to turbine classification, for the inventor insists that it is a turbine, is that the gears are driven as well by the impact as by the pressure of the entering air or steam. There is no intention, however, to produce a considerable drop between the steam chest and the admission pressure, and no nozzle or other means is used for inducing velocity. The width of the entrance port in the axial direction determines the point of cutoff. The regulation may be effected by varying the cutoff by an adjustable port, or

The secret of the large capacity of this little motor lies in the large displacement afforded by its numerous chambers and the high velocity at which their volume is increased.

Assume a gear 8 in. in diameter with teeth 1 in. in depth. The annular space between the roots of the teeth and the casing would have a cross-section of about 22 sq.in. As one-half of this space is occupied by teeth and one-half available for displacement on *each* gear, the available volume would be that of the whole space considered with reference to one gear.

Assume the length to be 24 in. and the speed 2000 r.p.m.; then the displacement will be

$$22 \times 24 \times 2000 = 1{,}056{,}000 \textit{ cu.in.}$$

or 611 cu.ft. per min., which is about that which would be generated by a piston 13¾ in. in diameter running at 600 ft. per minute.

It is possible, therefore, to get a large amount of power into a small weight and space with pure rotary motion, no pistons nor abutments, and with no necessity for packing. The surfaces of the teeth, as the gears drive each other, run in sufficiently close contact to preclude serious leakage; leakage between the tops of the teeth and the casing is minimized by the small pressure difference between contiguous grooves, and what steam is present between the teeth forms an elastic cushion reducing tendency to wear. The contact pressure imposed upon the teeth does not exceed 5 lb. per square inch, which is very small compared with that used with gears designed for power transmission. The ends being in the exhaust chambers do not require to be packed. The reaction of the steam as it escapes after its release at these points is another claim which is urged for classification as a turbine.

A little study of Fig. 1 will show that the steam is exhausted while the chamber in which it has been working is still above the center. There is, therefore, a greater pressure upon this upper surface than upon the under one. This unbalanced pressure is carried directly upon the bearings, which are made ample to withstand it, and are so constructed that each acts as its own oil pump, circulating oil between the shaft and bushings under a constant pressure. In the actual engine the under surface of the gears is the active one, the exhaust being on top. The weight of the gears is thus opposed to the unbalanced pressure. Or the gears may be set one above the other, as shown in Fig. 6.

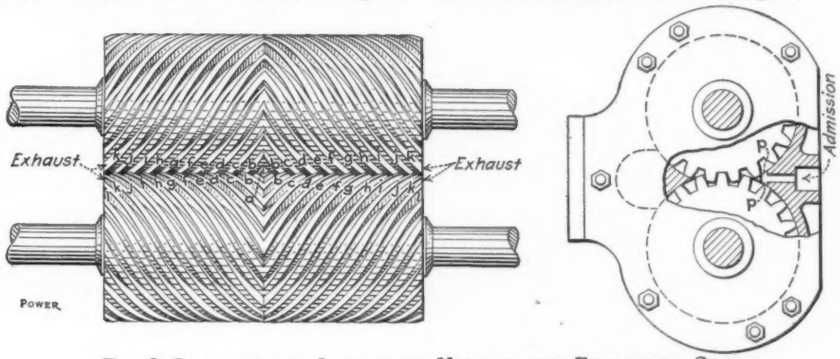
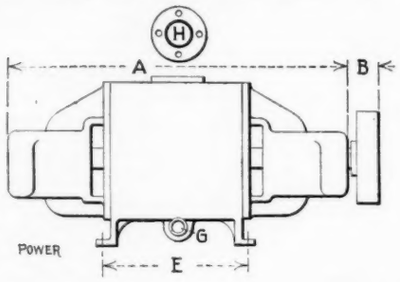
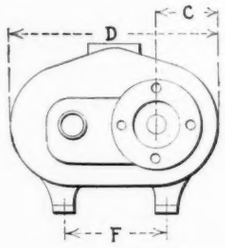


FIG. 2. SHOWING THE INCREASING VOLUME FOR EXPANDING STEAM

The "Spiro" is to be built in sizes all the way from small units, which may be held in the hand and used to operate drills and other air-driven tools, up to those of several hundred horsepower.

The rating is based upon 100 lb. gage initial pressure and 2000 r.p.m., noncondensing. Patterns up to 60 hp. are now ready, and the dimensions and weights are given in the accompanying table. The construction is extremely simple, consisting essentially of only five parts—the case, two runners and two heads, Figs. 4 and 5.





Hp.	A.	B.	C.	D	E.	F.	Steam Pipe G	Exhaust Pipe H	Wt. Turbine only
1– 3	16¾	3	2½	8¼	8¾	5⅜	¾	1¼	100
3– 5	19¾	3	⅝	9½	10⅜	6¼	1	2	175
5–10	30¾	3½	3½	11½	13½	7½	1¼	2½	300
10–20	36½	3½	4¼	14¼	16½	9⅜	1½	3	550
20–30	43¼	4	4¾	16	19¼	10¾	2	4	800
30–40	49	4½	5½	18½	22	12½	2	4	1200
40–60	57½	5	6	20¾	25¼	13½	2½	5	1600

We have known for some time of the work which was being done upon this motor, but the inventor and projectors have been unwilling that anything should be said about it until it had been thoroughly tried out. After three years of development and experiment they announce it as ready for the market.

The 186-hp. unit shown in Fig. 6 has been in use for three years by the Buffalo Forge Co., driving fans, gas scrubbers and other apparatus requiring a running test. It has never been taken apart, nor needed a single adjustment in that time. Noncondensing tests with smaller units show the following results:

	Test 1	Test 2
Boiler pressure, lb. gage	120	130
Initial pressure, lb. gage	101.5	115
Horsepower	25.3	151
Speed, r.p.m	2450	2710
Water per brake horsepower-hour, lb	53.2	31.8

The small hand motor, the rotors of which are shown in Fig. 1, will run a ¼-in. drill into hard cast iron at the rate of one inch in twelve seconds.

Fig. 3 shows a 5-hp. unit, being operated by steam from an ordinary tea-kettle; the ¼-lb. pressure which this kettle will carry being sufficient to start it and keep it in motion.

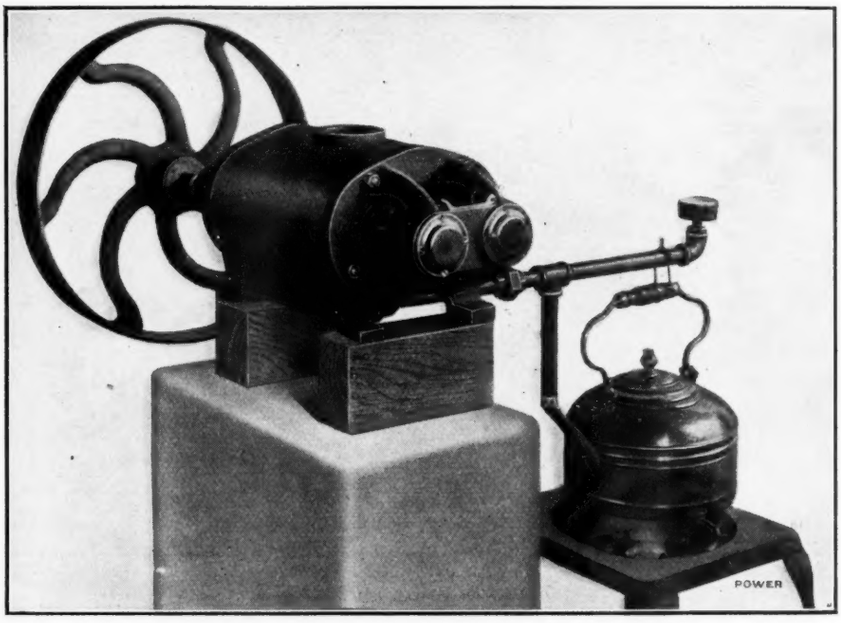


FIG. 3. A 5-HP. SPIRO RUN BY A TEA KETTLE

FIGS. 4, 5 AND 6. THE CASING AND HEADS, THE ROTORS AND UNIT OF 186 HP. CAPACITY

Lubricants, Their Properties and Uses

By Robert Jeffrey

Animal and vegetable oils, although containing acids detrimental to the metal surfaces, possess greater oiling properties than mineral oils and when blended with the latter make very satisfactory lubricants for certain purposes.

In special cases, however, only mineral oil should be employed.

*From a paper read recently before the Practical Refrigerating Engineers' Association, at Houston, Tex.

All animal and vegetable oils, fats, etc., contain acid constituents which will attack the metallic surfaces of bearings and form soaps of iron, copper, etc. The tendency which they have to become more acid with age is very slight in most cases, if the oils are properly refined and not stored too long.

Grease

When a grease is rubbed between the fingers they will slide freely over one another even when pressed together with considerable force. A similar effect is produced when a greasy finger is rubbed over a sheet of glass or other smooth solid. This arises from the fact that the grease is not a liquid or viscous substance, but a plastic or very soft solid which cannot by pressure alone be wholly driven from between the surfaces. On the other hand, the soft solid is easily sheared, the resistance offered to the sliding of particle over particle being very small. This property of greases causes them to form very thick lubricating films, even when the loads are heavy and the speeds moderate. At high speeds, however, they do not compare favorably with the oils, the frictional resistance being much greater; hence, except for special bearings, greases are now giving way to blended oils.

Greases are generally made by thickening a mineral oil, fixed oil or fat with a soap of lime, soda, lead, etc., more or less water being emulsified with the oil and soap. In some cases solids, such as black lead, French chalk and mica, are also added. They are liable to be adulterated with excess of water, and with solids such as China clay and gypsum, which are not lubricants.

Oils

The corresponding property in the case of liquids, which prevents the lubricants from being easily pressed out, is called oiliness. Different liquids possess this property in very different degrees. Thus, although sperm oil is much less viscous than glycerin, it will be found to be a much better lubricant. The viscosity of an oil, therefore, by no means furnishes an index of its lubricating value.

For ordinary speeds, moderate loads and good lubrication, it is no doubt the degree of fluidity which principally determines the value of a lubricant for any particular purpose; but when the speeds are slow or very high, the loads great, or the lubrication imperfect, oiliness as well as viscosity plays an important part in a reduction of frictional resistance. The property of oiliness is generally possessed most markedly by the animal oils, less so by those of vegetable origin, and least of all by some mineral oils. It is on this account that mixed oils are so frequently added to mineral oils, for they give the latter the property in which the mineral oils are most deficient.

Each particular animal or vegetable oil has a viscosity which does not vary greatly in different samples, and may be regarded as being in some measure an indication of its purity. The viscosity of such oils, therefore, need not be specified when ordering, but should be determined for the purpose of ascertaining the probable purity. Mineral oils, however, have a great range of viscosity, and it is necessary to state in all cases the degree of fluidity required. The viscosity of all lubricants varies considerably with the temperature. Thus, an oil which, as long as the journal runs cool, is sufficiently viscous to carry the load properly, may become so fluid, if the temperature should rise, that the rubbing surfaces tend to grip.

Mineral Oils

Mineral oils being much cheaper than the better grades of fixed oils, and at the same time possessing valuable properties which they confer upon other lubricants with which they are mixed, the use of blended oils has now become common. Apart from the pecuniary aspect of the case, the blended oils are for many purposes superior to either pure fixed oils or pure mineral oils. The percentage of mineral oil permissible varies according to the load, speed, etc., for many mineral lubricants are deficient in oiliness and can seldom be used pure, except in special cases or where bath rings or forced lubrication are used, and the journals and bearings are kept flooded with oil. At one time mineral oils were regarded with great distrust both by chemists and engineers, and when found mixed with fixed oils they were regarded as objectional adulterants. The reverse now seems to be the view often taken, fixed oils being sometimes looked upon as adulterants when found mixed with mineral oils.

Pure mineral oils are suitable for pressures below 70 lb. per square inch with free lubrication, when the metal surfaces in contact are such as do not readily seize one another. With increasing loads the proportion of fixed oils which it is desirable to add must also increase, if satisfactory results are to be obtained as regards friction and wear. From a chemical point of view there are good reasons for mixing as large a proportion of mineral oil with any fixed oil as will not interfere seriously with its load-carrying properties. By such admixture the tendency to gum is checked, the oil remains fluid and cotton waste saturated with it is much less liable to fire spontaneously. Animal and vegetable oils cannot, however, be added to all mineral oils with impunity; solid hydrocarbons are present in some mineral oils, which, when they are mixed with vegetable oils, separate out as a precipitate and cause trouble by clogging.

To clean surfaces which have become covered with a gummy oxidized lubricant, the parts should be well moistened with paraffin oil, which dissolves the gum. They should then be allowed to run for a few minutes, after which they may be wiped dry and clean.

A large number of lubricating greases are made by incorporating emulsifying animal and vegetable fats with soap and water, also by thickening mineral lubricating oil with soap. These greases are used with very good results on railway-car axles, and some of them are excellent lubricants for the bearings of slow-moving machinery. When the loads are exceptionally heavy, solids, such as plumbago and soapstone, are sometimes added to the grease. These solids prevent abrasion at points where the pressure forcing the surfaces together is very great. Except in special cases, however, greases should not be used for fast-running journals, shafts or spindles, as the frictional resistance which they offer to the relative motion of the surface causes great loss of power.

Impurities

Before rejecting any particular lubricant because difficulty has been experienced owing to the heating of the bearing supplied with it, care must be taken to ascertain whether the fault really lies with the lubricant or with impurities accidently introduced. In transparent oils these are easily seen, but in the thicker dark varieties they are almost entirely invisible. When oil contains such impurities as sand, mucilage, or precipitated paraffin, etc., which it very commonly does, and is poured into oil cups

in the usual way, the solids are filtered out or settle to the bottom of the reservoir and do not get into the bearings. But engineers frequently go round their engines and pour a little oil into the ends of the bearings, or even remove the oil pads and pour directly upon the bearing surfaces; this introduces grit at points where it can easily get between the rubbing surfaces.

Films of various kinds also settle on the trimmings or obstruct the oil passages and prevent the oil from finding its way with the necessary freedom to the working surfaces. To still further reduce the risk of small particles of grit entering into the oil cans, the lubricant, as it is given out for use, should be carefully strained through wire or cotton gauze when drawn from the tanks.

To enable nuts, boiler manholes and handhole plates, keys, etc., to be easily placed in position and removed again after standing for months or years in warm places, a lubricant is required which retains its qualities and does not evaporate, corrode or otherwise injure the metallic surfaces. For such purposes tallow or oil or greases containing it should on no account be used. No doubt they make the nuts, etc., work freely in the first instance, but in a very short time the fat undergoes a change which corrodes the surfaces together Even mineral oil, although it does not set up corrosion, flows out of the joint in the course of a few hours when heated, evaporates, and leaves the surface free to bind.

To prevent this, the best plan is to make use of a lubricant consisting of thick mineral cylinder oil or petroleum jelly mixed with blacklead. Here, even if the fluid or semi-solid portion of the lubricant should be driven out of the joint, the blacklead remains in the joint, keeps the surfaces free and enables the nuts to be easily tightened or taken off at any time without risk of breakage. The same applies to valves, valve fittings, etc.

Unnecessary Wear

Although it is impossible to so lubricate the cylinders and valves of a steam engine that there will be no unnecessary wear, it is impossible to obtain anything like the results, so far as friction is concerned. The piston and valves move to and fro in straight lines and do not tend to place themselves in such positions as to trap the oils properly and keep the surfaces from touching. Neither can the large extent of surface exposed be kept flooded with oil. Therefore, it is necessary to be content with the presence of a lubricating film of no great thickness, and either make the loads on the bearing surfaces small or cause them to move somewhat slowly.

Corrosion

Vegetable and animal oils are unsuitable for cylinder lubrication, as in contact with the steam at the high temperatures to which they are subjected, they undergo a chemical change resulting in the formation of free fatty acids which give rise to very serious corrosion. In many instances, the use of such fatty lubricants has resulted in the cylinder metal being rendered spongy and porous in the course of a few years; bolts, valves, spindles, studs and other parts have been cut quite through, and the cylinder joints, etc., rendered leaky. Fatty oils, however, when mixed with mineral oils, in quantities not exceeding 5 to 20 per cent., do not seem to produce these objectional results so readily; indeed, the lubrication of parts which have to carry very heavy loads is greatly improved by the addition of such oils.

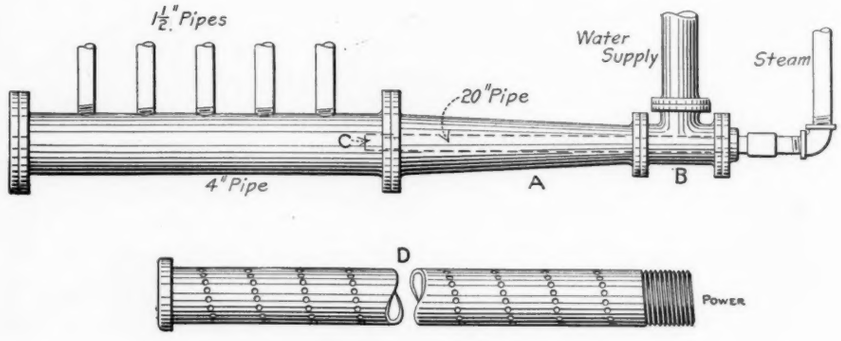
When surface condensers are used and condensed water is again passed into the boilers, care must be exercised to prevent the passage of oil used for lubrication of the cylinders into them. Tallow, suet, castor oil and other animal and vegetable lubricants must not be used in such cases, even in small quantities, for the acids liberated by the action of heat and water vapor pass into the boilers and cause serious corrosion. These acids cannot be separated from the water by merely allowing it to rest for a time in a tank; they remain to a large extent suspended in the water, giving it an opalescent appearance. Mineral oils also remain suspended in condensed water in a very fine state of division, and even though a considerable quantity may rise to the surface and be removed, sufficient may remain in suspension to produce a very serious effect upon the flues by so checking the passage of heat through the boiler plates as to cause them to burn.

The deleterious effects produced by the action of a lubricant on marine boilers when surface condensers have to be used, have led to marine engines being run without any direct lubrication of their valves or cylinders whatever, although a certain amount of oil finds its way in from the swabbing of the piston rods and valve stems. This can often be done without any serious wear taking place as the load on the rubbing surfaces of many well designed engines is very small, but with new engines slow speed must be adopted to begin with, and the surfaces allowed to burnish and acquire hard skins.

Heating Large Quantities of Water Quickly

A scheme for heating large quantities of water quickly is shown in the accompanying illustration. The device consists of a section of 4-inch pipe from which various outlets are run by means of suitable connections to various points of delivery. Connected to the flange of the header or manifold is a section *A*, 20 inches long. A tee *B* is fitted to this section and is reduced for a 1½-inch steam pipe *C* in which three hundred ¼-inch holes have been drilled spirally as shown at *D*.

The holes are drilled on a slant toward the capped end so that as the steam is forced through them it imparts momentum to the water, and the spiral arrangement of the holes produces a whirling motion which thoroughly mixes the water with the steam, thus permitting a large amount of water being heated with a small amount of steam. The water supply enters the section *B* at the top inlet.



Details of Header

Much has been written recently to impress the mind of the isolated-plant engineer with the necessity for keeping records of his plant's operation if he desires to check the inroad of the central station into his domain.

Comparatively few letters have come to this paper from engineers telling how they succeeded in repelling the central-station advances. These few letters are surely not an index of the amount of good work done along these lines by the many engineers of isolated plants, and it is hardly to be believed that these engineers are indifferent to the dangers that confront them in the activity being displayed on every hand by the central-station solicitor.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

The Holzwarth Gas Turbine

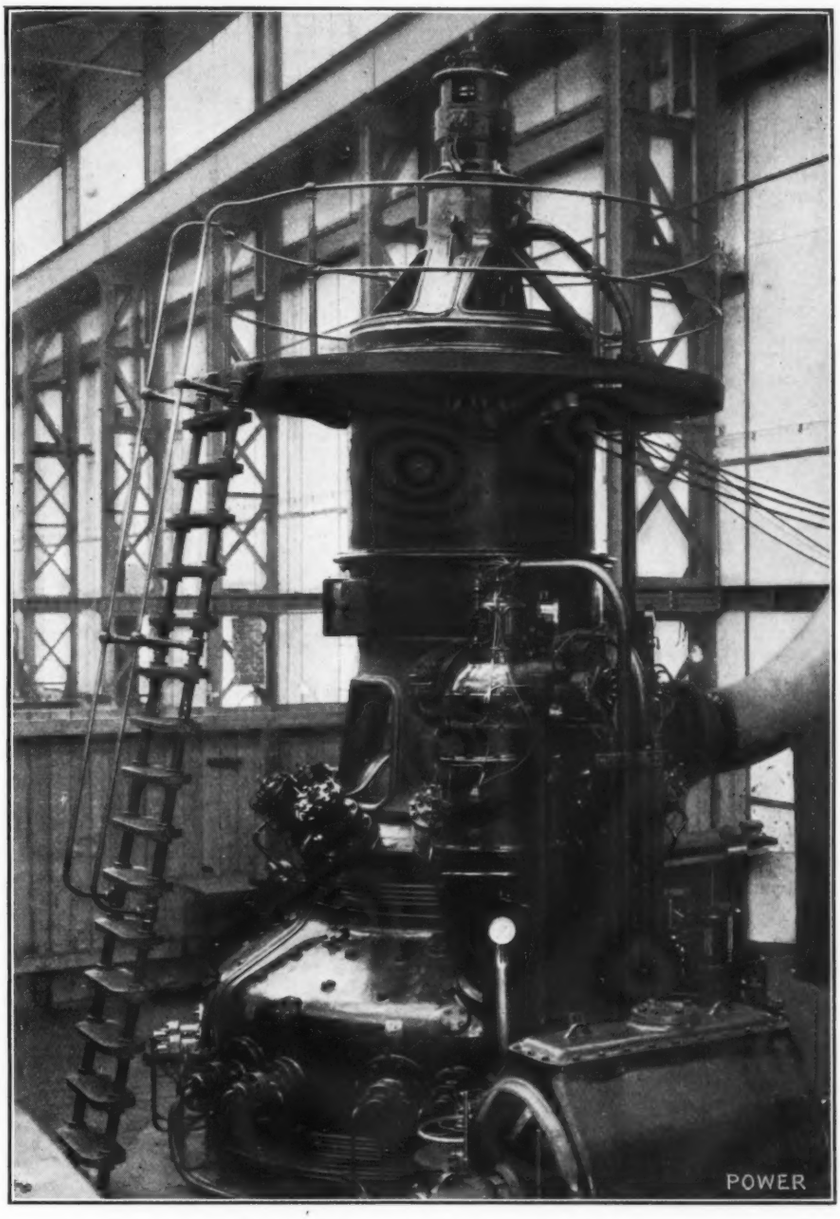
In a book just published in German, Mr. Hanz Holzwarth, a well known gas-engine designer, describes the construction of a new type of gas turbine which he is developing and presents the results of three years' painstaking experiments and investigations. This work is of a high degree of industrial importance, and the results obtained by Mr. Holzwarth are most interesting and should be valuable to anyone seriously interested in the gas turbine problem.

In a paper recently read by Mr. Holzwarth before one of the German engineering societies he pointed out that the history of the development of the gas turbine suggests two ways of solving the problem. In the one method, the mixture of air and gas is brought to the combustion chamber under the highest possible pressure, and there burned continuously; the outlet of the chamber is fashioned into a nozzle in which the compressed gases are expanded and a high velocity given to them, which with a proper form of turbine is converted into mechanical energy. This is the method of Lemale. The other method consists of intermittently burning the fuel in the combustion chamber and then scavenging the chamber with a cooling medium. This is the method Mr. Holzwarth has chosen.

Fundamental Principles

The combustion chamber is filled with the explosive mixture, then follows the ignition and explosion, the increasing of the pressure of the gases, followed by expansion through a nozzle upon a proper form of turbine runner; then a thorough scavenging and cooling of the combustion chamber with fresh air. Mr. Holzwarth's tests and investigations, he says, indicate that the explosion turbine is practicable only if the principle illustrated in Fig. 1 is followed. In this drawing *A* is the combustion chamber; *B* is the air chamber; *C* is the gas chamber; *D* is a mechanically controlled admission valve for air; *E* (not shown) is a mechanically controlled admission valve for gas (a spraying or atomizing nozzle to be used for liquid fuel); *F* is a nozzle valve; *G* is a nozzle; *H* is the turbine wheel; *J* is the exhaust passage.

By means of a blower of any sort, driven in any desirable way, the chambers *B* and *C* are filled with air and gas respectively, while a low pressure is maintained in the exhaust passage *J* by means of an exhauster. Through the admission valve *D* air is taken into the combustion chamber *A*; after the chamber is full of air, the gas is admitted through a similar valve, and the whirling thus produced causes intimate mixture of the gas and air. During this time the nozzle valve *F* remains closed. Immediately after the ignition, the valve *F* is automatically opened by the explosion pressure and the gases go through the short passage to the jet *G*, and acquire in it the velocity corresponding to the available energy contained in them.



Holzwarth's 1000-hp. Gas Turbine

This kinetic energy is converted in the turbine wheel *H* and the expanded gases pass off through *J*. After the passing off of the expanded gases the nozzle valve *F* is mechanically closed, but so slowly that

the scavenging air now entering through *B* has enough time to clean and cool the chamber and the turbine. A number of such combustion chambers are arranged in a circle around the turbine axis and their operation follows in definite rhythmical order.

The First Industrial Machine

Fig. 2 shows the construction of the first Holzwarth gas turbine built on industrial lines. It uses ordinary suction

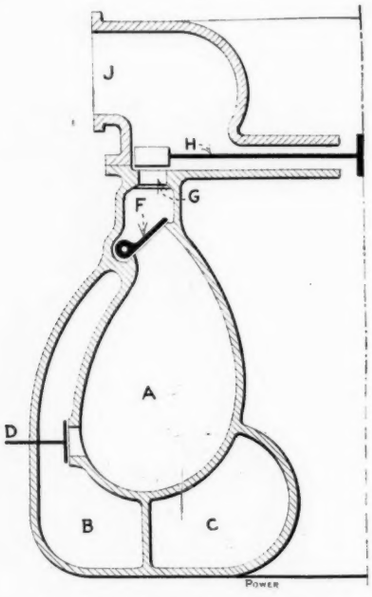


Fig. 1. Schematic Diagram

producer gas of 123 to 135 heat units per cubic foot and was designed for a maximum capacity of 1000 hp. at 3000 r.p.m. It was built to Mr. Holzwarth's design by the well known Swiss firm of Brown, Boveri & Co. With this machine the principal investigations and tests were made during the past year.

Upon the ring of combustion chambers is built the lantern frame for the dynamo, with the lower collar bearing for the turbine shaft. On the lantern the dynamo is set and above this the upper collar bearing and the "step" bearing. The turbine shaft, therefore, hangs freely suspended from the upper end, with the turbine wheel at its lowest extremity. The shaft passes through the turbine casing without a stuffing-box and there is no other structural element connected with the turbine case. The turbine wheel and dynamo rotor are mounted on a rigid through shaft with out any coupling as shown in Fig. 3.

The explosion chambers contain all means for the control of their own processes. About the assembled explosion chambers arranged in a circle are the gas chamber, the passage for the air, which if desirable is cooled with water, cooling water conduits, the gas- and air-admission valves and the nozzle valve. In front of the outlets of the explosion chambers the nozzles are arranged. The stationary blades of the turbine are likewise bolted against the upper part of the explosion chamber. The upper flange of the explosion chamber carries the lantern and the turbine case is also bolted to it, the case carrying the flanged opening for the exhaust.

The explosion chambers are given an ellipsoidal form; the lower end is pressed inward, the upper drawn down to accommodate the seat of the nozzle valve, as indicated in Fig. 2.

As material, Mr. Holzwarth considers that cast iron merits first consideration. The pressure need not run so high as in the piston engine, 10 atmospheres being

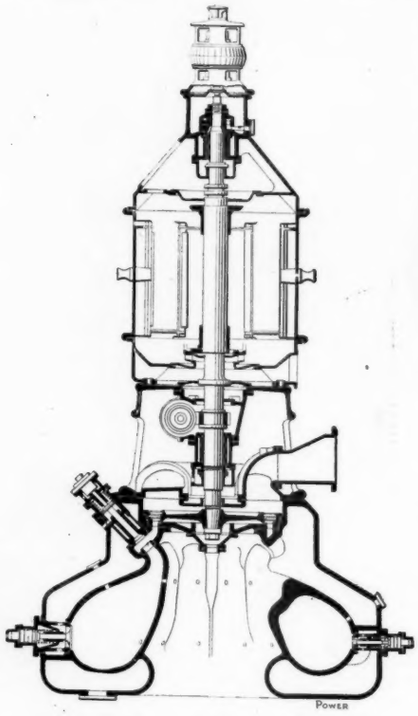


Fig. 2. The 1000-hp. Turbine

sufficient, and the automatic opening of the nozzle valve immediately after ignition avoids the possibility of damage from high pressure. Moreover, the Mellipsoidal form of the chamber is better adapted to resist internal pressure than a cylinder with equal thickness of wall. These features permit the use of a light-weight structure. The whole gas turbine, without the dynamo and blower, weighs some 25,000 kilograms (55,000 lb.), as compared with 140,000 kilograms (310,000 lb.) for a 1000-hp. piston gas engine without the flywheel.

As the air and gas valves regulate the supply of gas and air for the combustion chamber, there are as many air and gas valves as there are combustion chambers. On account of the multiplicity of organs, which in themselves are exceedingly simple, it is important that simplicity and dependability should characterize the method of speed regulation. For this reason the oil-relay principle is used, thereby avoiding a multiplicity of oscillating levers, pins, eccentrics, etc. There is only a piston to actuate each valve, the piston being moved by oil under pressure and controlled by means of a rotating distribution valve.

Each of the valves operated by oil under pressure is also provided with a device for periodic regulation, this being operated also by means of oil pressure under the control of the governor. Fig. 4 shows the construction of this valve. The body is bolted to the explosion-chamber ring, as shown in Figs. 2 and 5. The valve disk lies against a seat in the end of the valve body and the spindle slides in a bushing in the body and carries a piston at the other end. This piston is freely movable in another hollow piston, which is moved in the valve body by the oil pressure, and the movement of the hollow piston is transmitted to the

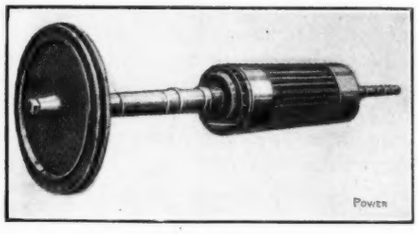


Fig. 3. Holzwarth Rotor

valve piston if the space between the valve piston and the closed end of the hollow piston is full of oil.

The function of the nozzle valve is simply to shut off the explosion chamber during the charging process. It is automatically opened by the explosion and held open during the ensuing expansion and the scavenging period. The

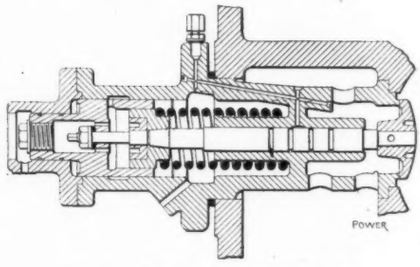


Fig. 4. Oil-controlled Valve

nozzle valve consists of the valve body, the valve with the spindle, a spring-loaded disk and the actuating piston, which is moved by oil pressure. The spring holds the valve closed with a pressure sufficiently high to prevent the escape of mixture during the charging process. After expansion is completed, oil is admitted to the actuating cylinder and holds the piston up and the valve open until the scavenging is accomplished.

The horizontal governor shaft is enclosed by a housing which is bolted to the lantern frame, and it is driven through a worm-gear between the lower collar bearing and the dynamo, as indicated in Fig. 5. Upon the governor shaft are keyed the governor; a safety stop, which in a simple manner cuts out the ignition; the tachometer drive; the worm-gear for driving the vertical regulating oil-distributor, and the drive for the ignition mechanism.

The regulating organ proper is the rotating oil-distributor. The pistons for operating the intake valves, nozzle valve, gas valve and air valve for one combustion chamber are controlled by one rotor and the several rotors are mounted upon a shaft which turns with an angular velocity corresponding to the number of cycles per chamber. In the stator of the

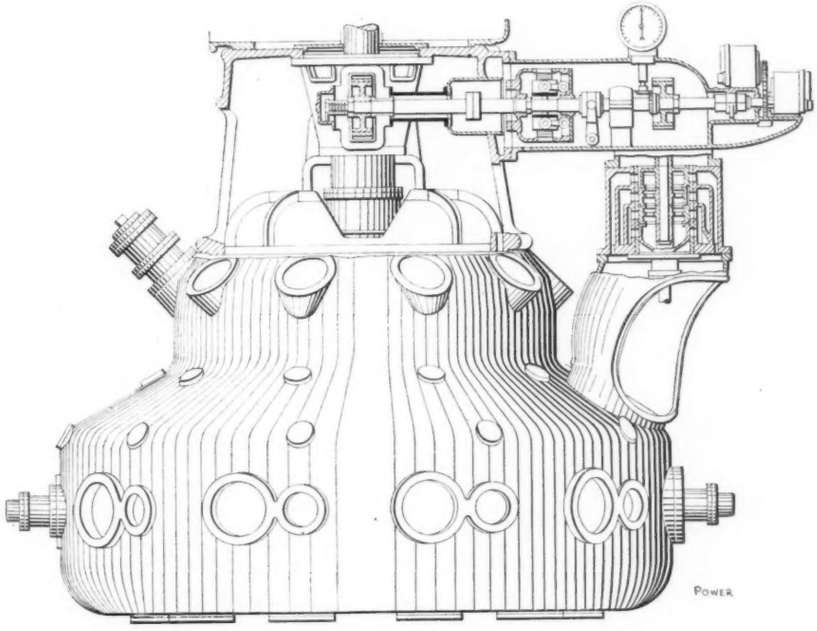


FIG. 5. SHOWING DETAILS OF GOVERNOR AND OIL REGULATOR

oil distributor are equally spaced axial slits which communicate with the oil cylinders of the valves. The oil is pumped under pressure into the rotor, from which it flows through the slits in the rotor and the slits in the stator to the valves, which are thereby operated in definite sequence. When the rotor opens the slit in the stator for that purpose, the oil flows back under the pressure of the valve spring to the space in the upper part of the distributor, and passes thence to the pump. The throttle valve, with the cylinder for periodic regulation, is also bolted upon the explosion chamber (Fig. 6).

The collar of the governor is connected with the horizontal lever of the governing mechanism proper. This consists principally of what Mr. Holzwarth calls a "servo-motor," operated by oil under pressure, the throttle valve and the periodic regulator. The servo-motor is of the familiar form comprising a cylinder, piston and pilot valve. The piston rod pushes downward upon the spindle of the throttle valve without being rigidly connected to it. At its upper end the piston rod carries a small piston for the periodic regulating.

The throttle valve differs from the normal construction in that it is opened by a spring. The throttle-valve spindle follows the piston rod of the servo-motor through only a portion of its stroke; the stroke, on account of the periodic regulation, is somewhat long, and it would be useless to give its entire travel to the throttle valve.

The periodic regulation is effected by means of a small control plunger, moved by the servo-motor piston rod and travelling in a bushing with lateral ports that communicate with the regulating spaces of the gas and air valves. Under the control plunger is the oil under pressure. Above it the oil can flow off freely. The higher the plunger is lifted, the more slits are exposed for the escape of the pressure oil and the more combustion chambers put into action.

The explosion efficiency will be the greater the greater the ratio of expansion and the lower the final temperature after expansion; also, the smaller the amount of heat lost to the walls, of course. It is identical with the indicated efficiency that would be obtained from the piston gas engine if the gas mixture were not compressed after admission and the expansion were carried down to the pressure of the atmosphere. The working process in the turbine proper corresponds with that of the older Parsons steam turbine, working with steam puffs. At the moment when combustion is complete, the chamber is full of gas containing the available heat energy. As the heat is taken out during expansion, the gas passes out with diminishing velocity until the heat fall is entirely equalized. Fig. 7 illustrates this intermittent process; *W* represents the work actually realized

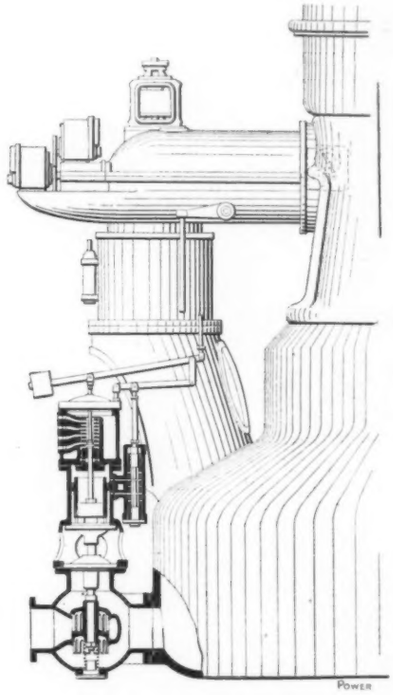


FIG. 6. SERVO-MOTOR

from *C* kilograms of charge; *L* represents the turbine losses and L+W= the work which would be accomplished by a perfect engine with no loss. The height *H* of the diagram represents the available heat in the gases.

The air scavenging is absolutely necessary in order to keep the temperature in the turbine within reasonable bounds (about 400 deg. C.). In order to secure economical scavenging and small radiation to the walls of the explosion chamber, it is well to have the greatest pos-

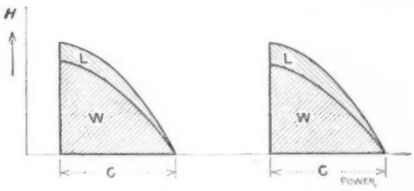


FIG. 7. HOLZWARTH CYCLE

sible nozzle-valve opening; for economical charging, this valve should be held closed, of course, during the charging process.

The blower work necessary to the process is effected by the utilization in a regenerator of heat from the exhaust gases. It is, therefore, not a burden upon the heat balance of the turbine. The surfaces necessary for the regenera-

tor Mr. Holzwarth says, are not greater than those of a surface condenser for a steam turbine of like capacity.

Temperature before Ignition

A point of considerable importance is the influence of the temperature of the mixture before ignition. Upon this depends the result of ignition: whether quiet (slow) combustion or violent explosion (detonation). Upon it depends further the stability of the process, and, preëminently, the explosion efficiency. It determines, therefore, whether the pure motor process or the undesirable heat process is effected by the combustion of the fuel.

Fig. 8 shows several pressure curves for carbon monoxide. By "combustion pressure" is meant in general explosive

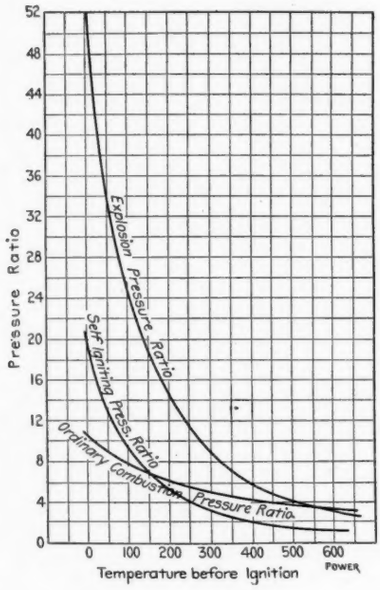


Fig. 8. Carbon Monoxide Combustion Characteristics

pressure or detonation pressure. The flattest curve shows the ratio of the pressures existing before and after ignition, with increasing temperature before ignition; the middle curve shows the ratio of critical compression pressure to precompression pressure in relation to the temperature before ignition; the upper curve shows the ratio of detonation pressure to pre-ignition pressure, indicating the explosion wave peaks which were reached as soon as the pressure reached the critical point of instantaneous, detonating self-ignition.

For example, should the temperature in the explosive gas before the ignition amount to 100 deg. C., the combustion, or explosion pressure, would be 7.7 times as great as the initial pressure. It is attained in some 0.03 to 0.06 of a second, through a regular, orderly flame propagation. In this case the critical temperature cannot be reached, for at 100 degrees this ratio to the initial pressure is 9.1.

Should the initial temperature, however, reach 400 deg. C., soon after the regular ignition half of the available gas would reach the critical temperature and the remaining half would be exploded spontaneously, and thereby produce a concussion up to 5.7 times the initial pressure while the regular explosion pressure would be only 4.3 times. At 200 degrees 14 times the initial pressure can be reached as against a normal of 6 times the initial.

This entirely unexpected and not always welcome increase of pressure does not bring a corresponding increase of capacity with it, for it is only momentary, not sustained. Fig. 9 illustrates this process.

The First Experiments

The first turbine designed by Mr. Holzwarth was a small experimental machine, which was built by Körting Brothers in the year 1908. The air for combustion, scavenging and cooling in this machine was delivered by means of a rotary blower and the fuel gas was supplied by a similar blower. Each blower was driven by an electric motor. After leaving the turbine wheel the exhaust gases, mixed with the scavenging air, passed through vertical pipes to the atmosphere.

The construction of this small experimental turbine was in principle identical with that of the larger turbine already described.

The object of the test with the first small turbine was to determine in the first place if the sought-for process was attainable, if the explosion would approach the theoretical possibility, if the scavenging and cooling were sufficient to permit sustained operation without endangering the machine mechanically, and if the vanes would stand the process. No one of these questions could be answered by the indications of other tests or by the analytical comparison of this with other machines.

The first difficulties were relatively easy to overcome. After a few weeks the machine ran mechanically perfect; the process was, therefore, practicable. No mechanical damage to the machine appeared; the nozzles and blading showed not the slightest signs of trouble, notwithstanding it was operated until the fire played upon the wheel. These tests were carried on with gas made from anthracite, and containing over 20 per cent. of hydrogen and somewhat heavy hydrocarbons.

Encouraged thereby, Mr. Holzwarth proceeded to the construction of an economical turbine adapted to the requirements of a power plant, and this was the 1000-hp. machine first described. The project was begun in 1909 and the erection was completed in the winter of 1910. Meanwhile, experiments with the small machine were continued. For fuel there were used lighting gas, heavy motor benzine, Roumanian gas oil, benzol and coal dust from various sources. Coal gas can be used in the same apparatus as power gas, but the travel of the gas valve must be materially reduced. The liquid fuels were generally pumped into the turbine by means of a Diesel injector and atomizer. The ignition remained the same (high tension jump spark).

Lighting gas gave not the slightest difficulty. Its high hydrogen and carbureted hydrogen contents made it possible to promptly ignite the entire contents of the chamber. All of the liquid fuels either pure or mixed with illum-

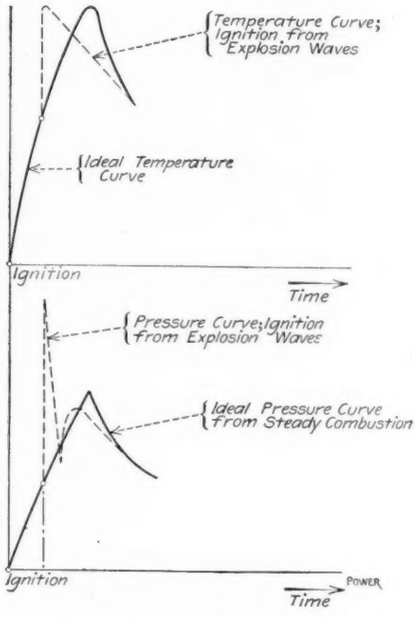


Fig. 9. Regular and Explosive Combustion

nating oil, can be brought to complete and smokeless combustion. It was necessary only to maintain the proper average temperature for each fuel in the explosion chamber, in order to prevent the coating of the spark plug with an insulating film of oil. In this way benzine, heavy benzine, heavy motor benzine and benzol could be exploded in the cold machine. The average temperatures that must be maintained in the explosion chamber are about 400 deg. C. for petroleum, about 400 deg. for gas oil and about 375 deg. for coal tar oil. That it should be possible to obtain in his turbine complete combustion of these heavy oils which have been hitherto usable only in the Diesel engine, was an agreeable surprise to the experimenter.

With coal dust, on the contrary, the results were not encouraging. Samples from different sources were tried. Only

the extraordinary gaseous, but also very expensive cannel coal produced regular explosions, but only 20 per cent. of the coal dust admitted was exploded; the rest could not, in the short time available, "find" the necessary air.

Early Experiments with the Large Turbine

In the tests begun last year with the large turbine the fuel was power gas made from coke the poorest gas in hydrogen and in heat content which was used during the series of turbine tests. While the fundamental questions were quickly solved in the light of the tests with the small turbine, the striving after the greatest perfection, uniformity of operation, more certain control of the results and the preclusion of accidents offered unsuspected difficulties—solely because fundamental physical precedents were not available and in the present state of knowledge could not be known. After the better and more perfect installation of the same system of oil control, which on the first using was successful, the process became unstable, at first good, and then worse. The inventor had succeeded in running at 3000 r.p.m. without loads, but with excitation sufficient to generate 4000 volts, with only 250 to 300 cu. in. of gas per hour, corresponding to an indicated efficiency of over 20 per cent.; certainly an encouraging beginning so far as efficiency goes, but always only transitory as to practical operativeness. The average temperature corresponding to the deterioration of the process rose considerably above the value which at the highest should be reached by calculation. At one time the entire contents of the chamber would be exploded, so that the theoretically attainable height would be reached. Again, only a part of the mixture was burned in the chamber and the remainder apparently in the turbine casing, which, of course, was not designed therefor.

These observations all point to the foregoing fundamental data upon the influence of the temperature before ignition, as well as upon the explosion waves and the efficiency of the explosion. They led to the cooling of the walls of the explosion chambers by additional water, reducing the temperature to the lowest point which it was possible to obtain, and to the taking in of the air directly through the air valves from the outside. The performance thereby obtained was much more stable and smoother, without the introduction of any disadvantage. At the same time, a noticeable improvement in ignition was obtained, so that the ignition and explosion occurred as perfectly as could be expected, taking into consideration the variations in the specific heat, and entirely without explosion waves.

Future Development

The further development of the turbine, Mr. Holzwarth says, is a question of working out and developing the working process in the turbine proper so that the calculated capacity may be actually attained. What steps must be taken to effect this may be indicated by the following results of his experiments.

With light charges and small explosion pressures, the performance was satisfactorily near the calculated results; larger charges and higher explosion pressures did not produce the expected increase of capacity. The difficulty was traced, by process of elimination, to the nozzle proportion. With five chambers at work, the explosions were regular and in conformity with theoretical determinations. The experimentally determined values lie between the theoretical curve for complete explosion based on an initial temperature of 15 deg. and the curve calculated on the basis of an initial temperature of 100 deg. C. With 10 chambers at work, however, the explosion pressures were materially below the values obtained when 5 chambers were in operation. With explosions up to 4.2 atmospheres, absolute, the apparent capacity per chamber lies between the values which would be calculated for an initial temperature of 15 deg. C., and those for 100 deg. initial; above 4.2 atmospheres, absolute, the average experimental values lie outside of the calculated region, the actual results being smaller than the calculations.

Further investigation showed that in this condition the nozzles allowed the jets to escape with strong sound vibrations. The explanation for the favorable and unfavorable results of this phase of the experiments was that the gas was not fully expanded in the nozzles when the initial pressure was above 4.2 atmospheres, absolute, and the jet velocity notwithstanding the increase of pressure, did not increase as it should. The gas when leaving the exist of the nozzle had not been expanded to the pressure maintained by the exhauster, and caused very strong vibrations in front of it.

These pressure waves among other things, prevent the necessary free exist of the exhaust gases when 10 chambers are at work. It seems, therefore, that the nozzles are not proportioned for sufficient expansion, and that their proportions must be determined not by the formula used for steam-turbine nozzles but by the use of entropy diagrams for the gas turbine.

No mechanical injury of any kind—wearing, erosion, etc.—was developed in the slightest degree, notwithstanding the tests have continued altogether for some three years. Mr. Holzwarth attributes this exclusively to the fact that no water in any form is used in the process; air cooling makes the use of any water entirely unnecessary.

LETTER

Failure to Run with Normal Compression

The query of "J. M. J.," in Power of Dec. 5, as to why a gasoline engine running all right with the compression relief cock open will not run under full compression with the cock closed, brings to mind a recent experience in trouble hunting.

The engine concerned is a 10-hp. single-cylinder Otto engine using illuminating gas as fuel. It has make-and-break ignition, a hit-and-miss governor and is started by hand, first shifting an auxiliary cam into position to open the exhaust valve during a part of the compression stroke in order to relieve the compression enough to enable a man to turn the engine over for starting. The engine is an old one and usually very reliable.

Last spring, however, the engine began "going dead" on moderate loads, first missing irregularly and finally stopping entirely. The peculiar feature of the trouble was that after stopping still, it never refused to start at first trial, although it would stop again after running a short time. In time it was discovered that the stoppage could be prevented by shifting the cams into the starting position, when the condition described by "J. M. J." was exactly duplicated, namely, satisfactory operation on low compression and refusal to run at all when the compression was normal.

The trouble was located in the ignition plug, where it was found that oil had formed a shunt circuit through the insulating material, an asbestos washer. The resistance of this path was such that when the compression was low, enough current passed between the plug points to make an igniting spark, but when the compression was normal, the increased resistance between the separated points prevented a spark being formed there. This source of trouble is quite rare with the make-and-break ignition system, though frequently encountered with the jump-spark system.

G. M. Wesley.

La Fayette, Ind.

Considerable new equipment has been added recently to the laboratories of the College of Engineering at Northwestern University at Evanston, Ill. It includes small Corliss and high-speed engines, a steam condenser with engine-driven vacuum pump, a gas engine, a hydraulic ram, a centrifugal pump, a small 60-cycle generator, an oscillograph, an electric blueprint machine and other appliances.

A Self Contained Lubricator

Generally speaking, the more self-contained a piece of apparatus, the better, for there are less exposed parts to be interfered with and hence there is less danger of derangement.

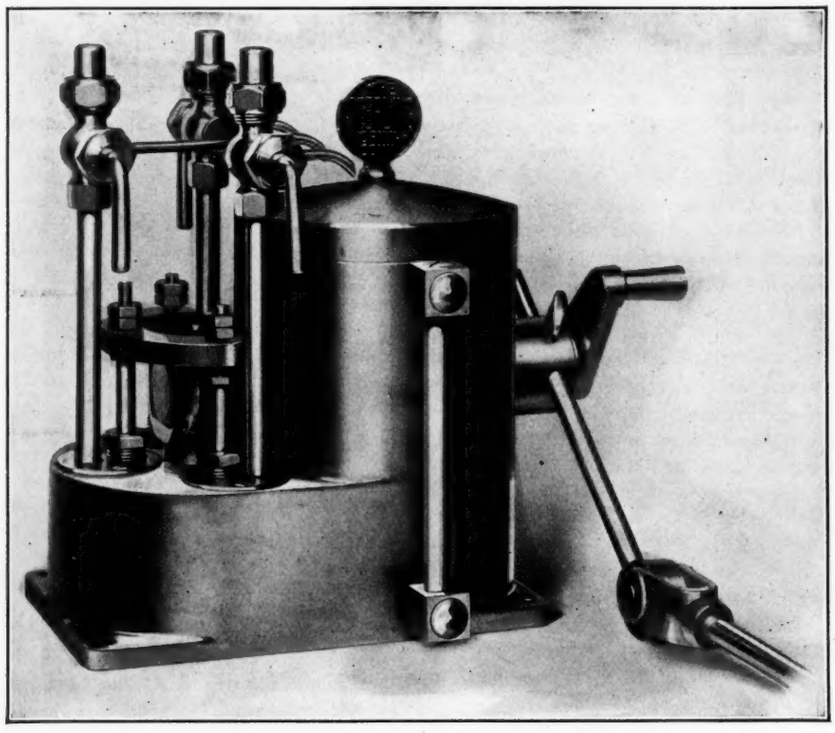


FIG. 1. THE IMPROVED STERLING MECHANICAL LUBRICATOR

The Improved Sterling mechanical lubricator, manufactured by the Sterling Machine Co., Norwich, Conn., and described herein, claims this feature. In Fig. 1, which is a view of a three-feed lubricator, it may be seen that there are no exposed gears, ratchet wheels or other similar parts, and the mechanism for operating the pump is contained in a recess in the oil reservoir.

The design and operation may be understood by referring to Fig. 2, which is a transverse section. The main operating shaft *A*, revolving in a journal formed in the casing of the reservoir, is driven by a set of four hardened-steel pawls which engage the steel ratchet wheel *B*. These pawls are carried in the hardened-steel driving hub *C* and are pressed against the face of the ratchet wheel by hardened springs as shown. The hub *C* is driven by the lever *D*, which is attached by means of a connecting-rod to some reciprocating part of the unit to be lubricated. The lever is fastened by means of the locking nut *E*, and hence it is a simple matter to vary the amount of rocking motion imparted to the shaft *C* by simply changing the effective length of the lever. A set of locking pawls *F* prevents any movement of the shaft *A* in the reverse direction.

The end of the shaft *A* projects beyond the casing and carries the cam *G* which operates the yoke *H*. This yoke drives the pump piston *I*. Attached to the yoke is a hollow shank which works in a hole in the main casing. This shank acts as a guide for the plungers, contains a felt wick and is filled with oil for lubricating the cam.

The action of the piston and double-ball valves is self-evident. There are two suction and two delivery valves in each pumping unit.

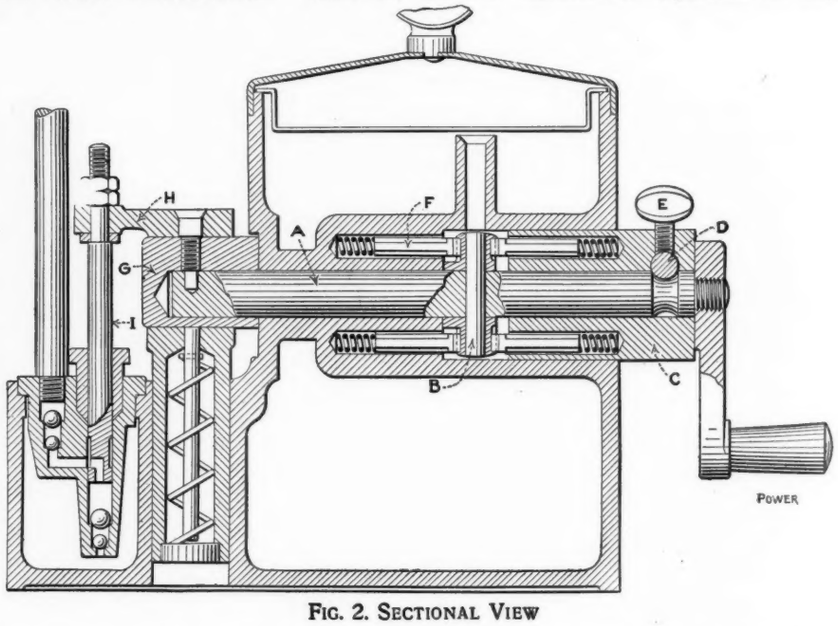


FIG. 2. SECTIONAL VIEW

Fig. 3 shows the delivery check valve and quill which may be used with this lubricator for dropping the oil into the center of the current of steam or air in the pipe leading to the part to be lubricated. The check valve has a double-ball check which allows the main check always to be covered with oil, thereby eliminating any chance of corrosion by steam.

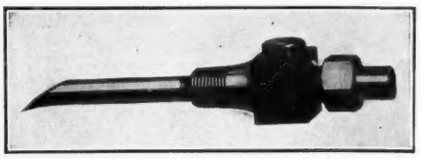


FIG. 3. DELIVERY CHECK VALVE AND QUILL

The points of superiority of this lubricator as set forth by its manufacturers may be summed up in the three words: simplicity, longevity and reliability.

Locomotive Boiler Explosion

While the Boston express train leaving that city at 4:30 p.m., and due in Syracuse at 2:45 a.m., on Jan. 26, was passing between Oneida and Wampsville, N. Y., the boiler of the engine exploded and the latter was completely wrecked. The engineer was instantly killed and it is believed that the fireman is fatally injured.

Up to the time of going to press the cause of the accident was unknown, but it is said that the water-supply pipe leading from the tender to the boiler may have become frozen because of the extreme cold, and that the injector therefore failed to force sufficient water into the boiler. As the thermometer registered 20 deg. below zero at Oneida on the night of the accident, it is also thought that the engineer's efforts to furnish heat for the passenger cars and still make his running time may have been a contributing cause.

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POWER

The Standard of Consulting Engineers

During the past few years numerous attempts have been made in New York State to force legislation compelling the licensing of consulting engineers. Whatever may have been the real motives behind them, one of the arguments advanced in support of the measure was that it would tend to raise the standard of consulting engineers and protect clients by preventing unqualified persons from practicing.

As is well known, all these attempts failed, chiefly because of certain provisions which made the measure inexpedient under existing conditions.

From recent advices, however, the members of the profession in England appear to have gone us one better; not by compulsory legislation, but by the establishment of an association of consulting engineers founded not only upon professional fitness but also upon a very high ethical standard.

The qualifications for membership state that a person must be a full member of the institute representing the particular branch of engineering which he practices; he must not in any way be connected with any firm with which he may have occasion to deal on behalf of clients, nor may he accept any commissions, discounts or other profits from any professional work upon which he is engaged, other than the fee from his client. Furthermore, he must not advertise or canvass for consulting work, act for a new client to the prejudice of an existing client, nor accept professional work in connection with which another member has been appointed, unless formally notified by the client of the termination of the former appointment. A disregard for any of these rules makes a member liable to expulsion from the society.

We do not know how large a membership the society has at present, nor do we venture a prophecy regarding its ultimate success. Its motives, however, are most commendable and it aims to lend dignity to the profession. Whether this can survive in the face of present commercial tendencies will be watched with utmost interest on both sides of the Atlantic.

Uniform Boiler Laws

It is stated that a determined effort will be made at the coming convention of the American Boiler Manufacturers Association at New Orleans, Mar. 12 to 15, to decide upon uniform boiler specifications, the adoption of which will be urged upon the legislatures of the various states of the Union and the provinces of Canada.

At present, there is a marked absence of any uniform rules regarding boilers in the several states. A few have laws which adequately cover both the construction and inspection of boilers; others provide only for the inspection and operation of the boilers, while the majority lack any state supervision over either the construction or operation of boilers, leaving the latter duty to the judgment of the particular district in which the boiler is located.

This condition of affairs is not only a menace to public safety but it is at times very embarrassing to the manufacturer. A boiler made according to the standard specifications of a manufacturer doing business in one state may, if carried to another state, have its allowable working pressure considerably reduced because it does not conform strictly to the specifications as enforced in the second state. Nevertheless, the rules of the first state may represent just as sound, if not sounder, engineering judgment. One of the first steps in drawing up uniform specifications would be to eliminate such incongruities in the law.

Some have advocated placing the construction and inspection of stationary boilers under Federal control, pointing out the rigid supervision maintained in the case of marine boilers and the consequently small number of explosions in this service. While such a course might possess certain advantages it would be

contrary to the states' rights, but there is no reason why uniform state laws, rigidly enforced, should not accomplish the same result.

Nothing to Do

A glimpse into an average engine room will often disclose the engineer leaning out of the window, sitting at his desk, or standing apparently idle about the room. Doubtless, it is this seeming idleness that has influenced some men to take up engineering as an occupation when they have no particular qualifications for it.

The engineering field presents great possibilities for advancement; there are also many chances for failure. The successful engineer does not find it necessary to go about his work in dirty clothing and with hands and face looking like those of a coal passer nor habitually to work with his hands.

Most of these men who apparently have nothing to do have passed from the stage of engineering drudgery to positions which require executive skill rather than manual labor.

No engineer who has attained success has seen the day when he had nothing to do. Even when his plant is in such condition that it will operate with but minor repairs during the year, he finds enough to keep him busy. The engineer who keeps his plant in readiness to deliver the load when the demand is made has had enough to do to get his machinery into the pink of condition, and is entitled to lean out of the window when he can find the time.

So far as the plant goes, there may be nothing to do; the boilers may be in good order, the engine and auxiliaries may be running as smoothly as it is possible to have them run.

But the progressive engineer realizes that there is something for him to do even when all of these satisfactory conditions prevail. He knows that he must look into the why and wherefore of this or that device; that he must find time to read on the subjects relating to his work, and that there are hours to be spent in weighing the evidence for or against making certain changes about the plant. All of this requires time, and while the engineer is leaning out of the window or sitting in his chair he may be studying out a problem the solution of which may mean economy for his employer.

No man is employed so constantly as the real engineer, the man who does things. If there are engineers who have nothing to do, they are not making the best use of their opportunities, and if they sit and twirl their thumbs it will not be long before there will be an opening in their plants for men who can make good.

Care of Internal Combustion Engines

The successful operation of the internal-combustion engine as a prime mover for the generation of electric power is not dependent upon any extraordinary professional skill on the part of the operator but upon his ability to exercise a little common sense and his willingness to keep things clean and in good order.

Cleanliness is, perhaps, of first importance and due attention should be given to the cleaning of the cylinders, valves, exhaust piping, etc., at stated intervals, to be determined by the kind of fuel used. For instance, highly carbonaceous gases will require more attention to internal cleaning than those having a high content of hydrogen and nitrogen. In some cases the quality of the fuel will necessitate a thorough cleaning at least once a month while in others two or three months may elapse before this is necessary.

A sharp scraper should never be used in cleaning the internal working parts of an engine, such as the rubbing surfaces and valve seats. A liberal amount of kerosene oil and a wooden stick will usually remove all of the incrustation and deposit without scratching or impairing the wearing surfaces in any way. The engineer in charge should also pride himself upon the external appearance of his engine and a general wiping up once or twice a day is not too much in order to have things looking neat.

Very often when an engine is not working as satisfactorily as it might, the cause is assumed to be leaky valves, and they are immediately reground, using emery for the purpose. This is a mistake because usually the use of emery will result in overgrinding, which is not only useless but shortens the life of both the seat and the disk. Pulverized pumice stone mixed with a little oil will answer the purpose quite as well and will practically eliminate the liability to overgrinding.

The question of proper lubrication is also an important one, particularly as regards the cylinders. The intensely hot gases which come in contact with the lubricating oil have an evaporative effect and tend to thicken the oil, forming a gummy lining on the wall of the cylinder. It is therefore necessary that an oil be used which is particularly adapted to this severe heat and fed to the pistons and walls of the cylinders at the proper rate. Too much oil is just as harmful and expensive as not enough, for the excess oil will be blown through the exhaust valves and tend to clog up the passages. The cheaper grades of oil are always more costly in the end than the more expensive kinds. Sometimes a very small quantity of finely powdered graphite mixed with the oil gives good results and imparts a smooth and glossy surface to both the piston and the cylinder. The best engine oil obtainable is none too good for the other parts of the engine.

In starting a gas or gasoline engine it is well to remember a few facts regarding the explosive qualities of the fuel. The proportions of gas and air have their limits for explosive effect; therefore, a mixture too rich in gas will usually not give any better results than a gas that is too lean. A little practice and experience, however, will soon teach the operator as to the mixture that will produce the best results and he should then mark the mixing valve so that he will always know in the future how to set it when starting up. Great assistance could be given in this respect if every builder of combustion engines would furnish complete and definite instructions with each engine sent out and give some practical lessons to the man who is to operate it. Some builders have adopted the latter policy, with excellent results; it should be general, however.

New York City has experienced another boiler explosion, the second within a few weeks. Both boilers were located under the sidewalk.

The new boiler-inspection department of New York City can do good work in cleaning out some of the old boilers now being operated in that city. No use waiting until they explode.

Readers with Something to Say

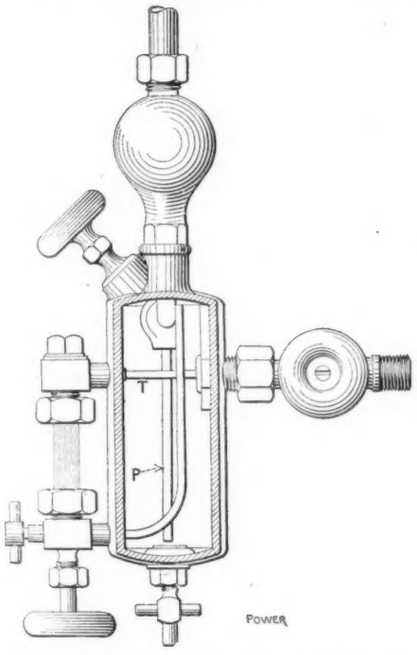
A letter good enough to print will be paid for. Ideas, not mere words, wanted

Lubricator Experience

The majority of engineers have had experience with sight-feed hydrostatic-condensing lubricators, and had the sight-feed glass fill with oil. There may be several reasons for this, but I have discovered what I believe to be the most common and likely of all.

I used to think that a stoppage in the oil-outlet passage of the lubricator was what caused it, but I found that this would simply stop the feeding, so I had to search in another direction.

I got the manufacturer's lubricator



SECTIONAL VIEW, SHOWING DESIGN OF LUBRICATOR

catalog, studied the descriptions and direction; carefully, and I soon got a fairly clear idea of the construction of the lubricator from a sectional cut, the one herewith shown.

Referring to the cut, *P* is a tube through which water from the condenser above enters the body and takes the place of the oil as it passes out through the curved tube. The oil enters the upper end of this tube and is forced downward through it by the pressure of the water. The oil then passes in drops up through the sight-feed glass, and across the upper end of the body through the horizontal tube *T*. The tube *T* discharges the oil into a heater, a vertical cavity formed on the inside of the body at the oil-feed outlet, as shown.

From the heater the oil passes out through the discharge shank and into the steam pipe or steam chest of the engine.

The heater described has dry steam in it when the lubricator is working, the oil and the water of condensation passing out at the discharge shank as fast as any accumulates. When first filling the lubricator and before starting the feed of oil, time should be allowed for the condenser and sight-feed glass to fill with water.

The water that fills the glass is formed from the steam condensing that enters from the heater through the horizontal tube *T*. After the glass has filled with water and oil is being fed in drops through it, the outgoing oil fills the tube *T*, thus preventing any more steam from getting into the sight-feed glass while the feeding continues. It can readily be seen that if any water in the glass at the time the feed is started is allowed to escape, no more water will get in to take its place, and therefore the incoming drops of oil will replace it.

If water leaks out around the packing-nuts of the sight-feed glass, or around the oil-regulating valve stem or gets past the drain plug, the result will be that the oil will take its place and will fill the glass from the top downward as the water escapes. Of course, when the glass fills with oil it is necessary to stop the feed and blow it out clean and let it fill with water before restarting the feed.

L. J. WATSON.

Port Huron, Mich.

Baffler Plug Caused Pound

Recently I took charge of a turbine station in which one of the turbines vibrated quite badly; a pounding noise could be heard in the vicinity of the step bearing.

The carbon packing was in need of repair and it was thought that this might have something to do with the pounding. When the packing was repaired and no improvement was observed, it was thought that the guide bearing might be loose in the holder but it was found to be all right.

We measured the flow from the step bearing and the amount was ample for this type of turbine, but it was observed that the flow came in squirts instead of a steady stream; this was our cue. We inspected the baffler plug, found that it had been sawed off and did not fill the barrel by 4 inches, and that it worked back and forth with the stroke of the step pump, thus causing the step blocks to grind.

A hole was drilled in the plug and tapped for a machine bolt, and the length was adjusted to prevent any movement of the plug.

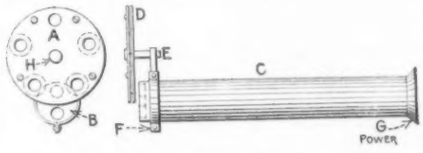
This cured all of the pounding noise and the trouble in the turbine.

WILLIAM BLACK.

Punxsutawney, Penn.

Home Made Smoke Tintometer

The home-made tintometer shown in the accompanying figure can be made by any engineer for a few cents and a little labor. The part *C* is a piece of tube (brass, tin, or iron) about 10 in. long. An eye-piece is formed by flaring out the end a little as at *G*. At the other end a piece is fitted and soldered on with two holes in it as at *B*. Two pieces like *A*



HOME-MADE SMOKE TINTOMETER

are cut with five holes in each, as shown, the holes to be of the same size as those in *B*. Four of the holes are glazed with pieces of tinted glass corresponding to the standard tints in some reliable smoke scale, any optician will supply the pieces for a few cents; the fifth hole remains empty. The glass is held in place by putting the two covers together and clamping them with four small bolts. A strap *F* is placed at the end of the tube and the tint case fastened so that it will revolve as shown at *D*.

The instructions for the use of this instrument are as follows: When examining the smoke from a chimney the observer turns the instrument so that the aperture, which is fitted with the revolving diaphragm, looks toward the windward side of the smoke; through this aperture he sees past the side of the smoke to the clear light of the sky beyond, the same light which is illuminating the smoke column.

Through the other aperture the observer sees at the same moment a circular patch which appears to be cut out of the column of smoke as it issues from the stack.

All that the observer has now to do is to revolve the diaphragm until both

apertures appear to have equal illumination, and a glance at the numbered glass will show in an instant if smoke is "light gray," "dark gray," "black," etc., according to the number on the smoke scale.

JAMES E. NOBLE.

Toronto, Ont.

Scale

The pile of scale shown in the accompanying picture is a four months' collection from a 60-hp. return-tubular boiler. Perhaps many engineers who do not have bad water to contend with do not know how fortunate they really are. This picture may serve to show them.

A FOUR-MONTHS' COLLECTION OF SCALE FROM ONE BOILER

A. A. DEVER.

St. Cloud, Fla.

Value of Engineering Journal

A full appreciation of the value of engineering journals and magazines can be obtained from a study of their purpose. Because a long article describing the products or manufacturing process of some company is sometimes published, it is occasionally thought that the object of the paper is advertising. But the real aim of most engineering papers is to furnish a medium through which useful and interesting knowledge belonging to the profession may be made public.

Most engineering practice is empirical. The degree of success of a project may be predicted with considerable accuracy if a similar scheme has met with success a number of times previously. This is the reason why the consulting engineer's office contains a reference library largely made up of current engineering literature. Here the engineering journal is of great value. It may be of value to the student in a similar way if the important and interesting articles are taken care of in some systematic manner.

The engineering profession at large would be extremely fortunate if it could believe all the statements made in its current literature. The fact that misstatements are made is not always the fault of the paper; sometimes it is. It is needless to say that a paper whose articles cannot be relied upon is worthless. It is well to avoid those papers which appeal to the popular imagination as, in order to make glowing statements, the truth is often distorted beyond recognition. Herein lies the strong point of the strictly engineering article; facts are set forth in the fewest possible words consistent with clear meaning, and rightly so, for the simple statement is worth the most.

One cannot read all the papers belonging to his chosen branch of the profession; he cannot carry too much ballast, else he sink. To get the most from his reading—for, after all, the benefit derived therefrom depends upon himself—he should read the best articles in the best papers treating of his branch of engineering, and read them thoroughly.

J. A. M. ROBINSON.

Chicago, Ill.

Repairing Boilers by the Welding Process

In a horizontal return-tubular boiler the rear head was so badly corroded and wasted away around the handhole that the inspector ordered a reinforcing piece to be put in. After the head had been cut away until only plate of full thickness remained, the reinforcing piece was slipped inside and four rivets, as shown in Fig. 1, were put in. The cutting of the head and of the handhole in the reinforcing piece was done with an oxyacetylene flame. The plate was then welded on the line indicated in the sketch and steel was welded over the rivets. I could not understand why the inspector ordered the rivets put in, as all of the strains are of compression, there being no part in tension. The boiler is under steam at the present time and is perfectly tight.

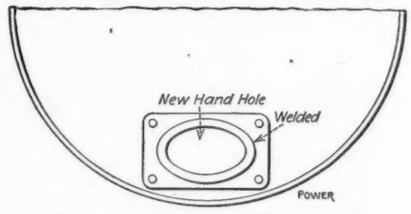


FIG. 1. REINFORCED HANDHOLE

Of a battery of seven Manning boilers, six were wasted away on the fire side of the furnace sheet so that it was deemed necessary to either cut out the sheet, part of the way around, for about 60 in. long by 8 in. high, or to build up the sheet by the oxyacetylene welding process. After carefully looking the matter up it was decided to try the welding. The metal to be added varied from ⅜ in. in thickness down to nothing and the area was about like that shown in Fig. 2.

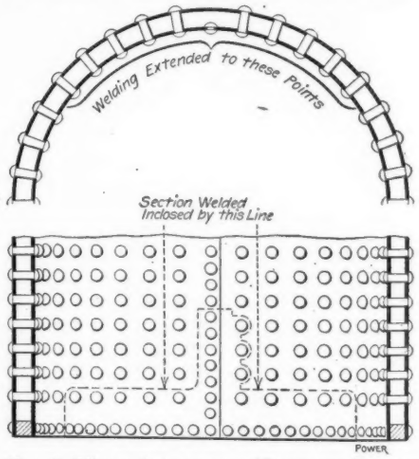


FIG. 2. WELD APPLIED TO MANNING BOILER

The reason for running up the vertical seam as shown in the figure was that the outside sheet had been trimmed so close to the rivets to get a calking edge that it was impossible to make the calking hold for any length of time.

The heads of the rivets in the bottom ring and the lower row of stay-bolts were welded over, as were the rivet heads at the vertical seam. The sheet around the bottom ring had to be built up below the rivets so as to get a calking edge.

Under hydrostatic test, six stay-bolts were found broken, probably due to expansion and contraction strains; also the fatigue of the metal must be taken into consideration as the stay-bolts had been in about 16 years. The advisability of welding the vertical seam is questionable, it being a lap joint, and expansion and contraction cracked the weld in places, necessitating the cutting away of the welded edge and calking of the joint. The welding of the fire-cracks around the door was successful.

It is evident that welding reduces the cost of repairs more than one-third and does away with the possible, and probable, future trouble with the extra seam in the furnace sheet had the work been done by cutting out the defective sheet and putting on a patch. Also, it was not necessary to move the boilers from their positions, a portion of the base plate, the grates and part of the outer covering being all that it was necessary to remove.

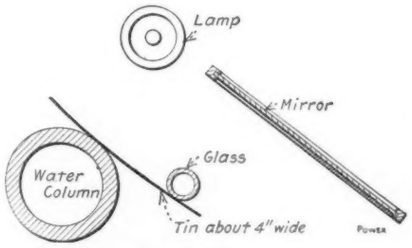
F. R. PRATT.

Adams, Mass.

Water Gage Illuminator

The accompanying figure is a plan view of the way in which I arranged a mirror and an electric light so as to make the height of water in the gage-glass distinctly visible from a distance as great as 65 ft.

I first took a piece of tin about 4 in. wide and as long as the glass itself. After whitewashing this on one side I



ARRANGEMENT OF LIGHT AND MIRROR

fitted it between the water column and the glass at the angle shown in the figure. I then hung a lamp and a mirror in the positions shown. The angle of the mirror is such that the height of the water can be seen from any point in the boiler room, either directly in the glass or indirectly in the mirror.

The empty glass forms a dark strip against the white background of tin, while the water shows up brightly and distinctly.

E. T. LEHMAN.

Chicago, Ill.

Noisy Heater

I have in my charge a Stilwell-Bierce heater. When I took charge of the plant the heater was used as a closed heater, but I soon found that the coils in it were not sufficient to heat the water to the desired temperature. The company would not buy any more coils so I decided to take out the coils and run the heater open.

The feed to the heater emptied in an overflow pan 10 inches below the baffle plate at the top and about 4 inches in front of the upper exhaust inlet. The first night I found that the feed water was as hot as it could be pumped and the heater did not make any noise. When I came on watch the next day at 12 o'clock I could hear a faint noise in the vent pipe of the heater. During the day there is but little load as most of the current is used for lighting, and we run only a 60-horsepower high-speed engine until evening. When I started up for the peak load with the 16x30-inch Corliss, one would think that there was a gas engine concealed in the heater.

I opened the heater and tried to find something loose inside but could not. I then fed the water on the top of the baffle plate and let it sprinkle through the exhaust steam. This did not help the noise. I then put in a bypass for the water from the boiler-feed line to the heater feeder. This helped some. The noise is not so loud and it is more regular; formerly it was intermittent like the exhaust of a gas engine. I never heard of a heater making a noise like this. If anybody has had this trouble I would be glad to hear how it was overcome.

L. C. GREENE.

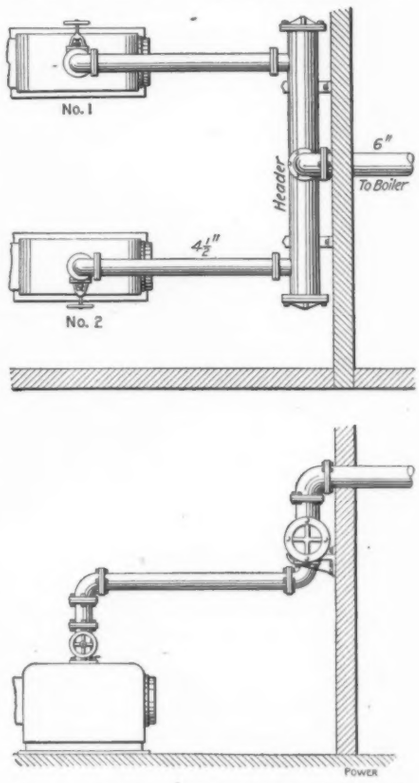
Gallipolis, Ohio.

Steam Pipe Vibration

It was my first shift in a new plant which consisted of two boilers and two Corliss engines belted to a direct-current generator. The engines were supposed to run at the same speed and were piped as shown in the accompanying figure.

No. 1 engine had been running alone all day as the load was light, but about 4:30 o'clock the night load started to come on and so I started up No. 2. Everything went along nicely for about 15 or 20 min., when the header and steam pipes began to vibrate in a manner that shook the whole building. This continued for about 5 min., when things settled down to quiet running again for nearly half an hour. Then, the vibration was repeated. As the pipe started to thump for the third time, I glanced at the valve-gear of the two engines, and the cause of the vibrations was a mystery no longer. The valve-gears of the two engines were in step or synchronized.

The steam header was so small that it could not supply steam to both cylinders at exactly the same moment without a drop in pressure. Therefore, just as the two engines got in step the header started to vibrate. I partly overcame the



PLAN AND ELEVATION, SHOWING PIPING

trouble by placing large separators close to the throttle valves of the engines, which should have been done when the engines were installed.

CHARLES FENWICK.

Wapella, Sask.

Sperm Oil for Cylinder Lubrication

I would like suggestions from POWER readers regarding cylinder lubrication. In the plant where I am employed it is necessary to use an oil that will not stain the goods, as exhaust steam is used to boil the water in which the goods are placed in the process of manufacture.

I am using sperm oil for cylinder lubrication in 15 high-speed engines which run at a speed of from 125 to 225 r.p.m., the cylinders ranging from 12 to 36 in. in diameter. This oil does not lubricate them unless I feed from 2 to 4 quarts of oil per day per engine, which comes heavy on my operating expenses.

Have any POWER engineers had experience with sperm oil as a cylinder lubricant, and have they any suggestions to offer as a substitute lubricant to meet my conditions?

J. BLACKNER.

Lowell, Mass.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

A Commercial Water Power Problem

The criticisms in the Jan. 9 issue of Prof. Ennis' article on the above subject, which appeared in the Nov. 14 issue, excited my interest, and I wish to criticize it still further.

In determining the value of a water power it is necessary at all times to consider under what conditions and at what cost the power can be generated, because it is on the cost of power generated by other methods in the plant that the value of water power depends. For instance, if a plant like the one under discussion has water power solely to help out its main engines which are of large capacity and, therefore, can be made to generate power at low cost, the comparison should be made upon what it costs to produce power by means of these engines when they are in such condition as they would naturally be put if the plant owner were using every possible means to operate the plant at the lowest possible cost.

It is evident from reading Prof. Ennis' article that the owners were operating an uneconomical plant and were making no attempt to improve it. An evaporation of 5 lb. of water per pound of coal should not be tolerated in a plant of approximately 2000 hp., and it shows a lack of energy somewhere as well as of commercial power conditions. Prof. Ennis figured that the coal costs 0.6875c. per horsepower-hour, representing a total coal cost, on the basis of 2000 hp. for 6000 hr. per year, of $82,500. He further says that a conservative allowance for labor and supplies would make the operating cost approximately 1c. per horsepower-hour. This figures to 0.3125c. per horsepower-hour, or $37,500 per year for these items alone, making the total cost of power, exclusive of fixed charges, $120,000 per year.

I question this allowance for labor and supplies. A conservative allowance for labor and supplies per day in a plant of 2000 hp., operating 20 hr. per day, is $28, with two watches of 10 hr. each. This amounts to 0.07c. per horespower-hour, or $8400 per year. If the coal bill is correct, the total operating cost should be $90,900 per year, which is equivalent to $45.45 per horsepower-year, exclusive of fixed charges, instead of $60.

If, now, the plant be put into proper operating condition and it be assumed that the coal is of good quality, 3 lb. per horsepower-hour should operate the engines, particularly as they are operated 20 hr. out of the 24, and, therefore, the standby losses must be small. Then, under these conditions the coal cost would be $49,500 and the labor, as before, $8400, although this is a little large, because with a reduction in the amount of coal used, the labor would naturally fall off somewhat. We will neglect this and assume the total operating cost to be $57,900 per year, which is equivalent to $28.95 per horsepower-year. It might, however, be worth while in this plant, as it is pretty badly out of shape, to rebuild it entirely, allowing $9 per horsepower-year for fixed charges on the rebuilding, which is a liberal estimate. This would bring the power cost up to $37.95 per horsepower-year.

The introduction of a condenser might save an additional half pound of coal per horsepower-hour and thus reduce the coal bill by $8250, bringing the total operating cost down to $49,650, which is equivalent to $24.83 per horsepower-year.

Figuring with Prof. Ennis on the same basis and neglecting the fixed charges on the water power, and, therefore, on the steam plant, the cost of 60.3 hp. developed from the stream would represent a yearly value of $1497.25. Capitalized at 6 per cent., this would represent $24,954.

If the fixed charge on the steam plant of $9.90 per horsepower-year is taken into account, to cover the condenser in addition to the main plant, the total cost would be $34.73 per horsepower-year.

Since the development of a water power ordinarily demands a considerable expenditure for dam, head gates, canal or penstock, etc., an estimate of $125 per horsepower is not excessive; it would fairly represent a cost of $12.50 as a fixed charge against the water power, including interest, maintenance, depreciation, taxes, etc. This subtracted from $34.73 would leave a relative value for the water power of $22.23 per horsepower-year or a total of $1340, which, capitalized at 6 per cent., would represent a value of $22,333, instead of the minimum value of $25,000 put upon it by Prof. Ennis.

I have assumed that under these conditions the plant is so located that the water runs from the head gates directly through the condenser and therefore no pumping is required. Also, the water required to condense the steam from this plant I have estimated would not exceed 1 cu.ft. per second; this is a liberal allowance. Then, there would be 23.07 cu.ft. per second left available for power purposes.

These figures indicate that the company could not afford to pay more than $1340 for the use of the water power. It is evident also that this value also represents the lease value; that is, the maximum price which the company could afford to pay for this water would be $22,381.

If there was any use for exhaust steam—which Prof. Ennis has neglected to state—and in large quantities, it might be that the power cost would be materially reduced from the figures here given. If this heat were not available from the exhaust steam of the engines, it would have to be supplied in some other way. Therefore, so long as a portion of it is available from the exhaust steam of the engines, the heat which still is required can readily be calculated and the coal necessary to produce it subtracted from the coal required for power, thus making a considerable reduction in cost. This affects the steam-power cost and the value of the water power.

As far as plant improvement is concerned, it is warranted, and that makes it unnecessary to pay an exorbitant price for water.

As regards the necessity of higher-priced attendants in the event of the installation of a condenser, there seems no reasonable ground for expecting that they would be needed. An engineer who is capable of handling a 2000-hp. non-condensing plant should certainly be capable of taking care of a condenser in addition, as the operation of a condenser requires no more experience than does that of an engine.

As a rule, it may be stated that the value of a water power is dependent, first, on its location; second, upon its reliability as regards continuity of stream flow, and, third, upon its size.

Considering item No. 1, a water power may be found which, while of considerable size and having potential value in its power, will be of no commercial value, as it is located too far from means of transportation in securing labor, supplies and the handling of finished products.

As to reliability, it is entirely a question of whether at minimum flow the water power is sufficient to supply all of the power required to operate the plant. If not, an auxiliary steam plant must be secured; and then the question arises, is it cheaper to utilize the water power with the additional steam power required and sacrifice a good location, or is it cheaper to develop a steam plant only and sacrifice the water for an advantageous location?

The third item is practically an extension of the second. The questions to settle in this case are: is the water power equal to the maximum demand that the mill is likely to reach? If not, is the saving during the time the plant is in operation by water power likely to be enough to offset the cost when the mill demands finally exceed the capacity of the water power and must be supplied by steam in addition to the water?

For any comparisons as to the value of water or steam, it is essential that the fixed charges be considered, as in many cases, especially on water plants, they are very heavy.

HENRY D. JACKSON.

Boston, Mass.

The following suggestions may serve to clear up the discussion by Messrs. Steely and Daugherty (in the Jan. 9 issue) and by H. D. Jackson, in the present issue, of my paper on "A Commercial Water Power Problem," in the issue of Nov. 14.

I fully agree that the value $41.45 per horsepower per year applies under the stated conditions only, and that the value of a water power in general depends entirely on local conditions. (See my book, "Works Management," pages 171 to 173.) This is an elementary principle, no doubt familiar to most readers of POWER. In undertaking to question the coal consumption and miscellaneous operating costs given in the paper, and in disregarding the remarks made therein in connection with "Improvement of Plant," it appears that at least one of the correspondents has lost sight of it.

It is not true that the power owners "cannot claim the water after it has gone below the dam." This depends on local arrangements. In the plant in question, the tailrace was a headrace for several mills at a lower level. Permission could not be obtained to pump therefrom.

The "roundabout method" for finding the mean head at the orifice which Mr. Daugherty criticizes was adopted in order to develop the arithmetical result without recourse to a formula for the proof of which a knowledge of calculus is necessary. It is roundabout, and to a mathematician unnecessarily so; but it is a method which every reader can understand. That is why it was used.

The only modification of statement which seems necessary is in connection with the remark that "the plant ran steadily." By this is meant not that there was a constant load of 2000 hp. for 6000 hours per year, but that during this time the load never fell below 60.3 hp. This might have been inferred from the context, but Mr. Jackson seems to have based certain objections on a different inference.

There was no intention of conveying the impression of great accuracy. Certainly it can only be said that the velocity is "about" 24 ft.—with an error possibly either way. It is best, however, to carry out arithmetical results a little beyond the limits of probable exactness in order not to add an unnecessary error of computation to those inherent in the assumptions.

WILLIAM D. ENNIS.

Brooklyn, N. Y.

Arrangement for Marking Keyways

I have been very much interested in the different articles in POWER showing how to mark keyways in Corliss valve stems. I will not criticize any of them, although I will still use my own rig for doing the marking.

It consists of a piece of iron with a

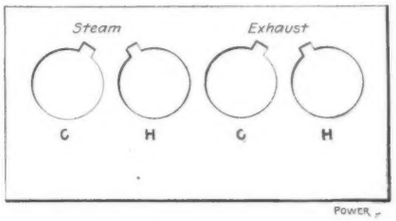


FIG. 1. PLATE FOR MARKING KEYWAYS

hole in it to fit the arm end of each stem. I put the stem in the proper hole and lay the T-end on a piece of bar of the right size to make the stem lie level. Then, I put the key in the keyway in the hole and mark the stem.

By this method I can get the stem all cut so that when I get the old stem out the new one is ready to put in to stay. I never have to change the valve rods.

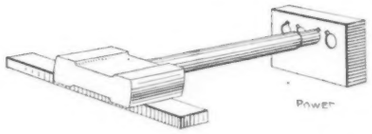


FIG. 2. SHOWING PLATES IN USE

Fig. 1 shows the way the face of the plate looks. I have one plate for each cylinder. Fig. 2 shows how I use the plate. It should lie on some level surface while the marking is being done.

F. W. BAIR.

Hancock, Mich.

Timely Discovery of Serious Lap Crack

I wish to make a correction to my article, "Timely Discovery of Serious Lap Crack," in the Jan. 2 number, in regard to the statement to the effect that Mr. Dennihan shut down in opposition to the wishes of the owner, who wanted to run until noon.

The owner, Mr. Cook, informs me that he was notified over the telephone that the boiler was leaking badly and that the engineer wished to shut down. Mr. Cook immediately gave orders to lower the pressure, and the shop was run for this purpose until the pressure was lowered. Mr. Cook also states that he ordered the boiler to be filled with cold water in order to lower the pressure more quickly.

LESTER A. FITTS.

West Fitchburg, Mass.

Responsibility for Defective Work

In the Dec. 26 issue, W. G. Walters describes the plugging and concealing of a wrongly drilled tube-hole in a return-tubular boiler head. I once had a similar experience, but, although the responsibility was traced to a man in the shop, he suffered no inconvenience other than a reprimand.

In this shop motor cars to run on railroad tracks were made. The wheels were put on the axles with a taper fit and pulled home with a retaining nut. The erectors received the axles and wheels from the machine shop, and when they were assembled, many of them failed to come up to gage. If too wide, they were reamed out; when too narrow, a piece of paper wrapped around the taper helped out wonderfully.

It made a very poor job, but the inspectors and testers frequently saw it done, the erecting foreman knew of the practice and I have an idea that the general foreman knew enough about it not to be over-inquisitive.

No complaint was made until the superintendent, in attending a convention, undertook to demonstrate one of the cars. In the course of the demonstration he pulled off a wheel to show what nice work was done in his shops. I do not know what else happened at that demonstration, but a day or so later the superintendent appeared in the shop with blood in his eye.

As in Mr. Walters' case, the trouble was traced to an erector, who took his calldown in a mild way, and a short time later was granted a raise in wages. Whether there was any connection between the two is hard to state.

One man may have improperly drilled the head, but it seems peculiar that he could tap, plug, chip, file and paint it

too before the tubes were put in without anyone being the wiser. Of course, in a small shop, with one man completing the boiler himself, this might have happened, but in a shop small enough for this it seems probable the foreman would have smelled a rat.

This is not written to discredit Mr. Walters' story in any way. In reading it I assumed from the tone of the letter that the author was connected with the buyers and not the manufacturers of the boiler, and that the latter would, of course, place the blame on the little fellow, just as the man killed in the boiler explosion is generally found to be to blame.

JOHN BAILEY.

Milwaukee, Wis.

Pipe Flange Bolting

I was much interested in the editorial in the Dec. 26 issue of POWER on the above subject, and agree with the writer, but I do not think that he carried the subject far enough.

In speaking of the man in the drafting room being responsible for the tap and stud instead of the through bolt, would it not be a good idea if this same man would also lay out the work so that all bolts and nuts could be reached?

How often one sees a case where for about half of the way around the pipe one cannot get the same leverage on the nuts as on the balance of them. When this is the case, it is almost sure that the nuts which are easy to get at are pulled up tighter than the others; therefore, an unequal strain on the flange is produced which in time is bound to cause a leak.

C. L. JOHNSON.

Newark, N. J.

Correction

There is a mistake in the printing of the formula for length of belt given by William Hirst in the issue of Jan. 9.

Twice the length of the hypotenuse is

$$2\sqrt{(R-r)^2+D^2}$$

The approximate formula on page 1125 of my "Pocketbook" (eighth edition) gives a more nearly correct result than Mr. Hirst's formula. Using his notation it is

$$L = 2D + \pi(R+r) + \frac{(R-r)^2}{D}$$

WILLIAM KENT.

Montclair, N. J.

In looking over the formula in Mr. Hirst's letter in the Jan. 9 issue, I found that apparently he had made a mistake in stating it.

The formula which I use, and probably the one which he intended to state, is

$$2\sqrt{(R-r)^2+D^2}+(R+r)\,3.1416=L$$

The result obtained by this formula is exactly the same as the answer given by Mr. Hirst. Thus it is quite clear that his mistake was simply in writing out the formula.

VICTOR JUMP.

Caledonia, Ohio.

Leaky Corliss Valves

In two recent issues of POWER there appear comments on leaky valves on Corliss engines. I agree with the writer who says that they are rarely ever tight. As a result of close observance for 25 years, covering hundreds of examples, I have found that engines working under 80 or 90 lb. steam pressure that have previously been carefully fitted will be found reasonably tight; but when 150 lb. pressure is carried they tend to leak badly. Some horrible examples have been found in engines fresh from the shops of even the most reputable builders. Thus it appears that temperature has much to do with the matter for large temperature variations combined with heavy pressure change the form of the cylinder casting and valve seat.

The remedy is to do as one writer suggested: File the high spots, making frequent examinations until a fit is obtained and the contact surfaces of both valve and seat are uniformly bright. This writer suggests draw filing the high spots, but I have found that the average workman is afraid of doing anything. Many times I have taken the roughest bastard file I could buy and "razeed" the valve ends; often I have done this a second time after a day's run, and even a third time. When the valve began to show bright in the middle of its length, I would finish up with a good "mill-saw" file, filing around—not draw filing.

One writer mentions making the steam valves a "trifle smaller than the bore," thus allowing them to lift in case of water in the cylinder, etc. This idea is correct, but the method is wrong. The valve should be turned to fit the bore, but the top half of the circle on the ends should be cored away not less than $\frac{1}{16}$ in. on a 5-in. valve. This will be hard for the lathe man to caliper for size, but a small lug or rib can be left on top from which to caliper, and be cut away after the valve is turned up. This form is a great safeguard against damage by water.

I have seen many valves broken in the middle by water while no great damage was done to the engine elsewhere, and if the valve could have lifted, the distress might have been passed without damage. This form of valve will be likely to have a "click" if compression is run up to or near the initial pressure; the remedy is not to run the compression so high.

W. V. WHITE.

Cincinnati, Ohio.

Brick for Boiler Walls

In discussing Lewis L. Scheiderer's suggestion of using hollow brick for boiler walls, as printed in the issue of Jan. 9, I would say that while I have not had experience with such brick I would not deem it of any merit, as recent experiments with boiler walls, with and without air space, show conclusively I believe that a solid-brick wall is the better insulator of heat. If this is true, the rule would likewise apply to walls built of hollow bricks, and to a far greater degree.

VICTOR BONN.

New York City.

Induction Heater

In a short paragraph in the issue of Jan. 9, on the page of "Inquiries of General Interest," under the title, "Induction Heater," we would like to call attention to the last sentence, which states that "induction heaters are used in places where it is not convenient to place a thoroughfare heater." We criticize this to the extent of saying that the question of convenience is the least often brought up in arguments concerning the merits of thoroughfare vs. induction heaters. It is usually a question of economy and safety. The induction heater is capable of being connected up in a less expensive manner and as no bypass is necessary there is no possibility of damaging the heater through a misuse of the valves in the bypass.

There are also other reasons for the use of the induction heater which might briefly be mentioned as follows: (1) the steam does not pass through the heater body before going to the heating system or the atmosphere and therefore does not become water-soaked in passing through the spray chamber of the heater; (2) there is no possibility of exceeding the capacity of the oil separator when additional steam units are turned into the main exhaust line, and (3) the induction heater is the only one which can be arranged so as to reduce back pressure.

WARREN WEBSTER & CO.

Camden, N. J.

Our contemporary, *Engineering News*, expresses the belief that it would be a most useful thing to engineers in this country if the Bureau of Mines, which has already made a detailed study of the operation of several kinds of power generators, should collect and publish a body of facts on the operating costs for medium-sized steam-engine plants.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Power Required for Compressing Air

How much air can be compressed per minute to 225 lb. gage pressure in a compressor driven by a 3-hp. engine?

A. D. M.

Assuming the initial pressure in the cylinder to be 2090 lb. per square foot, the compression of 1 cu.ft. of free air per minute to 239.7 lb. per square inch, or 34,516.3 lb. per square foot, will require 0.2743 hp. With an overall efficiency of 80 per cent., this would mean

$$\frac{0.2743}{0.8} = 0.343 \; i.hp.$$

to be delivered by the steam end. Thus three horsepower under these conditions will compress

$$\frac{3}{0.343} = 8.746 \; cu.ft.$$

of free air per minute.

Power Factor of a Feeder

How is the power factor of a feeder found when the branch circuits have different power factors?

G. G.

The power factor of the feeder is the reciprocal of the square root of 1 plus the square of the quotient of the sum of the product of the current and the inductance factor of each branch circuit divided by the sum of the product of the current and power factor of each circuit. Expressed as a formula, the rule would be as follows:

$$p = \frac{1}{\sqrt{1 + \left(\frac{I_1q_1 + I_2q_2 + I_3q_3}{I_1p_1 + I_2p_2 + I_3p_3}\right)^2}}$$

p = Power factor of the feeder;
I = Current of each branch circuit;
$q_{(1,2,3)}$ = Inductance factor of each branch circuit;
$p_{(1,2,3)}$ = Power factor of each circuit.

Putnam Engine Valves

Why is more lead given to the head-end than to the crank-end valve of a Putnam engine?

L. P.

Owing to the angle which the connecting-rod makes with the center line of the engine, the piston travels faster when leaving the head end than the crank end of the cylinder, and more lead is given to the head-end valve to insure full pressure on the piston at the beginning of the stroke.

Taking Ammonia Out of the System

How can the ammonia be taken out of a compression ice-plant system without losing any of it?

P. McD.

If the plant is of ordinary construction and design, connect an empty shipping tank to the bottom connection of the liquid-ammonia receiver; have the tank on a scale and weigh the amount of ammonia put in; do not allow more ammonia to enter the tank than it originally contained when shipped; that is, not more than five-eighths of its cubic contents. The chances are about even that, unless a man is thoroughly familiar with the above operation, he will burst the compressor, or blow up the receiving tank and possibly lose his life.

Flow of Steam in a Pipe

What amount of steam will flow through a 4-in. pipe 100 ft. long, the initial pressure being 80 lb. and the terminal pressure 38 lb.?

G. F.

Divide 3.6 by the diameter in inches; add one to the quotent, and multiply the sum by the length of the pipe in feet. Call this product 1. Then multiply the difference between the initial and the terminal pressures by the fifth power of the diameter and by the density of the initial pressure. Call this product 2. Divide product 1 by product 2 and multiply the square root of the quotient by 87. The density of the steam at 80 lb. is 0.2151. Applying figures to the rule, it would be expressed thus:

$$\sqrt{\frac{0.2125 \times (80 - 38) \times 4^5}{100\left(1 + \frac{3.6}{4}\right)}} \times 87 =$$

$$\sqrt{\frac{0.2125 \times 42 \times 1024}{100 \times 1.9}} \times 87 =$$

$$\sqrt{\frac{9139.2}{190}} \times 87 = \sqrt{48} \times 87 =$$

$$6.9282 \times 87 = 602.75 \; lb. \; per \; min.$$

Efficiency of a Condensing Engine

How does the extra power of the vacuum make a condensing engine more efficient?

P. J. O.

The vacuum in a condenser is not a power, yet it occupies the anomalous position of increasing by its pressure the capacity of the engine for doing work. This is because the atmospheric pressure or resistance which is always ahead of the piston in a noncondensing engine is, in a condensing engine, removed to a degree corresponding to the height of the vacuum, and makes available just so much more of the pressure behind the piston. If there is an average pressure of 40 lb. behind the piston and a vacuum of 26 in. is maintained in the condenser, there will be 13 lb. of resistance removed from the front of the piston, thereby making available 40 + 13 = 53 lb. per square inch.

Weight of the Flywheel

How is the weight of a flywheel found?

A. M.

Requirements and conditions differ so materially that it is difficult to give a general rule; different kinds of work will admit more or less variation. A rule to determine the weight is: Multiply the area of the piston in square inches by the stroke in feet and by 12,000,000 for average work. Divide this product by the square of the number of revolutions per minute multiplied by the square of the diameter of the wheel in feet. The quotient will be the required weight of the rim in pounds. Assume an engine of 20-in. cylinder diameter, 48-in. stroke, 75 r.p.m. and the flywheel 20 ft. in diameter. Using figures, the rule would be expressed:

$$\frac{314.16 \times 4 \times 12{,}000{,}000}{75^2 \times 20^2} = \frac{15{,}078{,}680{,}000}{2{,}250{,}000}$$

$$= 6701.6 \; lb. \text{ or } 3.35 \; tons$$

The constant will range from 10,000,000 for light-service engines to 15,000,000 for engines driving generators.

Low and High Speed Engines

What advantage has a low-speed over a high-speed engine?

E. D. G.

The low-speed engine, especially the four-valve engine, is usually more economical of steam than the single-valve high-speed engine, because its heat losses through the cylinder walls and its friction are less in proportion to the amount of steam used on account of the greater cylinder volume of the low-speed engine.

Water Power Valuation on a State Line

An interesting example of the complications sometimes occurring in water-power valuation is illustrated by a recent decision of the Massachusetts Supreme Court in the case of the Blackstone Manufacturing Co. vs. Blackstone.

The petitioner owns a water privilege and mill in Smithfield, R. I., and also owns land on both sides of the Blackstone River in Smithfield and in Blackstone, which are adjoining municipalities. The Blackstone River runs through Blackstone and Smithfield, and then into Blackstone again. The question before the court was the method of determining the value of the portion of the water power in Blackstone, and the decision approves prorating the total value of the water privilege, exclusive of the power house, on the basis of the amount of fall in the river on each side of the line as developed by the company.

It was contended at the hearings that the special part of the unit privilege which is contributed by the privilege belonging to the land in Blackstone was incapable of valuation; that the valuation of the land and structures in Massachusetts based upon their participation in the value of the whole single water-power development was necessarily a valuation of property in Rhode Island, and that any tax upon this was a violation of the Fourteenth Amendment of the United States Constitution.

The court dismissed this contention and pointed out that, as a matter of law, it is not impossible to make a fair estimate of the relative values in the two states sufficient for assessment purposes.

Coaling Steamers in German Ports

The Hamburg-American line, writes U. S. Consul-General R. P. Skinner, having over a million tons of shipping under its own flag, has perfected special bunkering arrangements at Hamburg whereby whole German carloads of coal are discharged into hatches. Ordinary shipping is bunkered at the rate of 95 pfennigs ($0.226) per ton, and coal can be delivered into hatches at the rate of from 25 to 30 tons per hour per gang. Coal is discharged from the holds at the same speed, but the unloading charge is 65 pfennigs ($0.155) per ton.

At Kiel, bunkering from the quayside is done for 1 mark ($0.238) per ton, or if brought from coal cars, 1.80 marks ($0.428) per ton. If a vessel lies in midstream the charge is also 1.80 marks per ton. Ten tons per hour per gang can be loaded. The coal-discharging fee at Kiel is 35 pfennigs ($0.083) per ton for men working on the vessels who fill the baskets, or 70 pfennigs ($0.166) if coal is unloaded directly into railroad cars or wagons. Coal can be discharged at the rate of 300 to 400 tons per day.

The Lubeck charge for discharging coal is 85 pfennigs ($0.202) per ton; for bunkering, from wagon into bunker, 70 pfennigs; from the barge into bunker, if about level with the ship, 90 pfennigs ($0.214) per ton; or from barge into bunker, if scaffolding must be built, 4 pfennigs ($0.009) or more per ton additional, according to the difficulties encountered. From 20 to 30 tons can be bunkered per hour from coal yards or from lighters, and from 50 to 70 tons can be discharged per hour.

Boston Engineers Club

The Engineers Club of Boston, recently incorporated along the lines of the New York Engineers Club, has decided to take an option on the building at 2 Commonwealth Ave., under lease with the privilege of purchase. On remodeling the building, facilities will be afforded the Boston technical societies in many respects similar to the United Engineering Building in New York. It is expected that the building will be ready for occupancy early in the fall.

Its officers are Ira N. Hollis, president; Charles L. Edgar and Charles T. Main, vice-presidents; Luzerne S. Cowles, secretary; Eliot Wadsworth, treasurer, and a board of governors.

OBITUARY

Charles W. Houghton, for 24 years a faithful and respected employee of the Ashton Valve Co., of Boston, Mass., died on Jan. 18.

George Schuyler Davis, vice-president and secretary of the Kenfield-Davis Publishing Co., Chicago, Ill., and editor of *Electric Traction Weekly*, died, on Jan. 24, at his home in Cleveland, at the age of 37. Mr. Davis was a charter member of the Central Electric Railway Association and an associate member of the American Electric Railway Engineering Association.

SOCIETY NOTES

The tenth annual banquet and reception of the combined N. A. S. E. Associations of Pittsburg, Penn., was held at the Monongahela House on Thursday evening, Jan. 25. After the banquet a pleasing entertainment was given, at the close of which dancing was indulged in by the 500 guests. The combination included Pittsburg No. 3, Allegheny No. 5 and Columbia Association No. 15.

On Tuesday evening, Feb. 13, the American Society of Mechanical Engineers, with the American Institute of Mining Engineers coöperating, will hold a meeting on California gold dredging. Robert E. Cranston, of Marigold, Calif., will present a paper entitled, "Notes on Design and Mechanical Features of the California Gold Dredge." An interesting discussion is also expected from a number of the members of both societies.

The combined associations of the N. A. S. E. of Philadelphia held their third annual concert, dinner and dance at Lulu Temple, on Friday evening, January 26. The audience of about six hundred listened to an entertainment given by the New York "Bunch," and then adjourned to the dining hall, after which dancing was enjoyed. Quaker City No. 1, Tacony No. 9, Merrick No. 12, and Northeast No. 20 were the associations comprising the combination.

PERSONAL

Fred L. Johnson, recently of the editorial staff of POWER, is now with the Brooklyn Edison Co., in the office of the chief operating engineer.

Will M. Glass, of Pasadena, Calif., has accepted the position of day-shift engineer of the Hotel Alexandria, at Los Angeles, said to be the largest hotel power plant in southern California. Previous to this position Mr. Glass was engineer for the Pasadena municipal lighting plant for about five years.

B. A. Brennan, recently contract manager of the Westinghouse Machine Co. and formerly with the E. P. Allis Co., has been appointed sales manager of the power department of the Bethlehem Steel Co., with headquarters at South Bethlehem, Penn., in charge of gas-engine and pumping-engine sales.

C. F. Hockley, for the past three years engineer in the power department of the Bethlehem Steel Co., has been appointed superintendent of the construction power department of that company, with headquarters at South Bethlehem, Penn. Prior to his present association, Mr. Hockley was identified with the Westinghouse Machine Co., East Pittsburg.

BOOKS RECEIVED

ENGINEERING AS A VOCATION. By Ernest McCullough. David Williams Co., New York. Cloth; 201 pages, 5¼x8 in.; illustrated. Price, $1.

THE GASOLINE MOTOR. By P. M. Heldt. *The Horseless Age*, New York. Cloth; 506 pages, 5x8½ in.; 341 illustrations; tables; indexed. Price, $4.

COMMERCIAL DYNAMO DESIGN. By William L. Waters. John Wiley & Sons, New York. Cloth; 135 pages, 5¾x9 in.; 30 illustrations. Price, $2.

MARINE STEAM TURBINES. By Dr. G. Bauer, O. Lasche and M. G. S. Swallow. The Norman W. Henley Publishing Co., New York. Cloth; 214 pages, 5¾x9¼ in.; 103 illustrations; tables; indexed. Price, $3.50.

Moments with the Ad. Editor

"How do the ads strike YOU?"

This was the substance of this page two weeks ago. We asked for free expressions of opinion from engineers on different ads in the Selling Section, particularly inquiring what ads seemed to the engineers to have the widest *educative* value, in fixing in a reader's mind the name of a certain product for a certain need.

A lot of engineers have already written in. Their letters are extremely interesting reading. But, before we say anything about these or publish any of them, we want *more letters*. We want YOU to write.

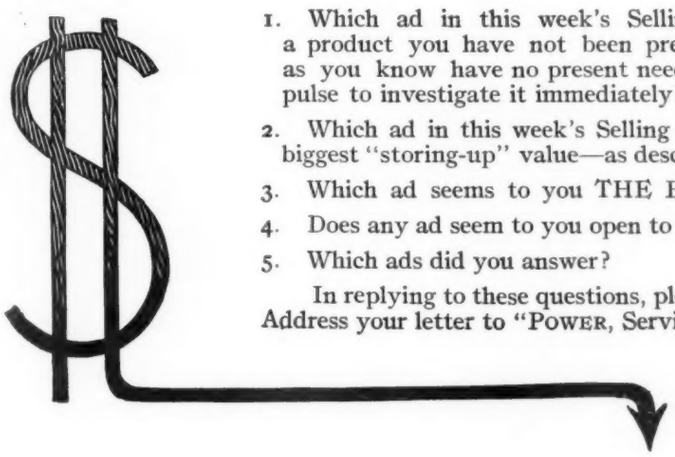
Let us know what ads in this week's issue, or last week's issue, *pull the eye* strongest, and why.

Let us know what ads *stir you up* to thinking about power-plant subjects in which you have not been interested very much thus far.

Let us know what ads seem to store your minds best with the name of a particular brand in connection with certain points—that is, what ads are building most strongly in your mind, week by week, a link between a particular name and particular product, and so impelling you to investigate *that kind first*, as soon as your own need comes.

Let's have some straight talk on this week's ads!

These are the questions we asked two weeks ago, which are here repeated:



1. Which ad in this week's Selling Section of POWER, describing a product you have not been previously interested in and so far as you know have no present need for, gives you the strongest impulse to investigate it immediately? Why?
2. Which ad in this week's Selling Section seems to you to have the biggest "storing-up" value—as described above? Why?
3. Which ad seems to you THE BEST, in every way? Why?
4. Does any ad seem to you open to improvement? If so, how?
5. Which ads did you answer?

In replying to these questions, please write briefly and to the point. Address your letter to "POWER, Service Department."

The best answers will be published in these columns and paid for at the regular rates.

NEW EQUIPMENT

Macksville, Kan., will install a municipal electric-light plant.

Berlin, Ont., will install electric pumps in the water-works plant.

Truro, N. S., is considering the installation of a municipal electric-light plant.

Kentwood, La., is considering the installation of a municipal electric-light plant.

Springfield, Ohio, is considering the installation of a municipal electric-light plant.

Barberton, Ohio, is considering the installation of a municipal electric-light plant.

Edgar Metcalfe, Moville, Iowa, is considering the installation of an electric-light plant.

The Southern Sierras Power Co., of San Bernardino, Calif., will construct a substation at Perris, Calif.

J. J. Beemer, Pawpaw, Ill., is considering the installation of an electric plant for street lighting purposes.

Littleton, N. C., will install a municipal electric-light plant. Estimated cost, $10,000. T. J. Miles is mayor.

Atchison, Kan., is considering the construction of a municipal electric-light plant. C. D. Walker is mayor.

Burns, Ore., is considering the construction of water-works and sewer systems. Estimated cost, $60,000.

Chillicothe, Mo., is considering extensions to its municipal electric-light plant. Estimated cost, $10,000.

Marquette, Neb., is considering the installation of a municipal electric-light plant and water-works system.

Bonds for $25,000 have been voted for improving the water-works system at Etna, Allegheny post office, Penn.

Bonds for $25,000 have been voted for improving the water-works system at Etna (Allegheny post-office), Penn.

Ellensburg, Wash., is considering several improvements to its municipal electric-light plant. Estimated cost, $35,000.

A permit has been granted to the Goodyear Tire & Rubber Co., Akron, Ohio, to construct an electric-light plant.

A filtration plant of 20,000,000 gal. capacity will be installed by the city of Erie, Penn. B. E. Briggs is city engineer.

The Exchange Ice & Cold Storage Co., recently incorporated, Los Angeles, Calif., will build an ice-manufacturing plant.

Bonds for $10,000 have been voted for the construction of a water-works system, Leonard, Tex. Bids will soon be asked.

Bryan, Ohio, is considering improvements to the municipal electric plant and water-works system. Estimated cost, $46,000.

Newton, Iowa, will install four new boilers at its municipal electric-light plant. C. O'Leary is engineer of power station.

The East Liverpool Ice Co., East Liverpool, Ohio, will erect a modern ice plant of 50 tons capacity. Estimated cost, $60,000.

The Forest City Electric Light & Power Co., Forest City, Iowa, will rebuild its plant. Ole Thompson is chief engineer.

The United Illuminating Co., New Haven, Conn., will build an addition to its power plant. G. L. Clock is chief engineer.

In connection with its new hotel building the Salt Lake Brewing Co., Las Vegas, Nev., will build a modern cold-storage plant.

Mountain Grove, Mo., has voted bonds for $20,000, for a water-works system. Hollen Kelley is city clerk and W. S. Candler, mayor.

The Quincy Valley Water Users' Association, Quincy, Wash., plans for the erection of an electric power plant near Wenatchee Lake.

The Big Springs Ice & Manufacturing Co., Big Springs, Tex., will install new machinery and double the capacity of its ice plant here.

Cuthbert, Ga., will soon begin work on the construction of a municipal electric plant. J. B. McCrary & Co., Atlanta, Ga., are engineers.

St. Louis, Mo., will install boilers and pumps for the water system. Estimated cost, $300,000. E. E. Ball is superintendent of water-works.

Camden, N. Y., is considering improvements to its municipal electric-light plant. Estimated cost, $18,000. Horace McDaniels is engineer.

The Erie County Electric Co., Erie, Penn., is planning the construction of a power plant on Peach St. T. J. O'Dea, Erie, is general manager.

The Toronto Suburban Ry., of Toronto, Ont., will build a number of new lines and will require additional power-house machinery and rolling stock.

The Northern California Power Co. is considering the construction of a substation at Princeton, Calif. E. V. D. Johnson, Redding, is manager.

The Chatham Gas & Electric Light Co., Chatham, Ont., will purchase gas engines, motors and other equipment for an addition to its power house.

Osceola, Ark., will build a new municipal electric-light plant. Estimated cost, $30,000. W. N. Gladson, Fayetteville, engineer in charge. Noted Dec. 26.

The Meriden Electric Light Co., Meriden, Conn., is considering the construction of an addition to its power plant. J. W. Clark, Meriden, is chief engineer.

Filters and a new pump house will be installed at the municipal water-works plant at Fort Smith, Ark. Estimated cost, $100,000. M. H. Reed is city engineer.

The Winters Light & Milling Co. has been formed, at Winters, Tex., with a capital of $10,000. The incorporators are J. L. Allred, A. F. Roberts and A. K. Doss.

A contract for connecting the water system of Victoria, B. C., with Sooke Lake has been awarded to the Westholme Lumber Co., Ltd., of Victoria, at $1,169,720.

The American Radiator Co., with principal offices in Chicago, Ill., will construct a plant for the manufacture of heating apparatus in Birmingham, Ala., to cost about $1,000,000.

Fox Lake, Wis., will receive bids until 8 p.m., Feb. 14, for a complete water-works system, including pumping machinery. J. C. Williams is president water-works commission.

The Sac City Electric Co., Sac City, Iowa, is considering the installation of an ice and refrigerating machine in connection with its electric plant. R. W. Richardson is general manager.

The Middletown Electric Light Co., Middletown, Conn., will install new steam turbines, condenser and boiler in its power station. T. N. Golden is general manager. Noted Jan. 20.

The Southern California Edison Co. is considering the reconstruction of its Santa Monica, Calif., system. The estimated cost is $30,000. W. A. Brackenridge, Los Angeles, is general manager.

The Board of Control of Winnipeg, Man., will receive bids until 11 a.m., Mar. 1, for a 5,000,000-gal. horizontal turbine pump driven by an induction motor, direct-connected. M. Peterson is chairman.

The Catawba Ice & Cold-Storage Co. will erect a 75-ton ice plant and cold-storage plants at Spencer and Salisbury, N. C. A 25-kw. dynamo will be installed. D. J. Rose, Rocky Mount, N. C., is the architect.

The Hoosier City Boiler Manufacturing Co., Marion, Ind., has been incorporated with a capital of $100,000 by J. I. Stephenson, J. M. Brocher, J. A. Sebastiana, J. M. Stephenson and M. A. Downing.

The Clingman-Hall Machinery Co., Plainview, Tex., will soon begin putting down a series of wells for irrigating an 18,000-acre tract of land. In all about 25 wells will be dug and pumping outfits installed upon each.

The Adams Gas Engine & Tool Co., Greenwich, Conn., has incorporated with $50,000 capital to manufacture gas engines and special tools. Incorporators are Charles F. Waterbury, Hezekiah Weed and Walter H. Adams.

Bids will be received by the State Commission on Lunacy, Albany, N. Y., until 3 p.m., Feb. 14, for heating, plumbing and electrical work in the Central Islip State Hospital. F. B. Ware, Albany, N. Y., is State Architect.

The city of Columbus, Ohio, is considering the installation of new equipment in the water-works plant, and the construction of a 6-ft. conduit, four miles long. Estimated cost, $600,000. Hugh K. Lindsey is superintendent of water-works.

Bids will be received by the city of Altamont, Ill., until about May 1, for constructing water-works and sewer systems, and installing pumps and other equipment. The Fuller Coult Co., Chemical Bldg., St. Louis, Mo., is consulting engineer.

Work will be started in the spring on the new factory building on Stillman St., Bridgeport, Conn., for the Boone Folding Box & Printing Co., 137 Cannon St. The building will be 25x50 ft., three stories, of brick. A freight elevator will be needed.

The contract for the construction of Section 3, Lexington Ave. subway, Tri-Borough subway system, New York, N. Y., has been awarded by the Public Service Commission to the Underpinning & Foundation Co., 290 Broadway, New York, at $2,295,086.

The Indiana National Life Insurance Co., Indianapolis, Ind., has purchased ground in North Meridian St., and will erect a modern eight-story office building to cost above a half-million dollars. The building will have its own water, light and heat plant, also a vacuum-cleaning system. Work is to begin in the spring.

The borough of Emaus, Penn., will receive bids until 8 p.m., Feb. 5, for the installation of a double-action pump, with a speed of from 50 to 100 r.p.m. and capable of delivering from 200 to 400 gal. of water per min.; also for one 80-hp. horizontal tubular steam boiler, 150 lb. pressure, including all necessary fittings, stack, stack plate, feedwater heater of sufficient size and injector.

British and Canadian capitalists have formed the Eastern Canada Power Co., capitalized at $100,000,000, to dam the St. Lawrence River, near Montreal, and develop 1,000,000 hp. Sir Max Aitken, a member of the British Parliament, is at the head of the company. The plan is to divert the St. Lawrence at the Coteau and Cedar Rapids and take the waterway about half a mile from its present course.

NEW CATALOGS

Toledo-Flanner Boiler Co., Toledo, Ohio. Catalog. Flanner water-tube boiler. Illustrated, 36 pages, 6x9 in.

Kerr Turbine Co., Wellsville, N. Y. Bulletin No. 20. Kerr turbo-blowers and turbo-pumps in gas-plant service. Illustrated. Bulletin No. 22. Turbo-generator sets for lighting. Illustrated.

The Burt Manufacturing Co., Akron, Ohio. Catalog. Oil filters, exhaust heads, ventilators. Illustrated, 128 pages, 6x9 in.

The Mirrlees-Watson Co., Ltd., Scotland St., Glasgow. Bulletin C 31. Combined hydraulic- and steam-turbine installation. Illustrated, 16 pages, 8x10 in. Bulletin No. C 31. Mirrlees-Leblanc rotary air pump. Illustrated, 4 pages, 8x10 in.

BUSINESS ITEMS

Owing to their fast increasing business in Louisville, Ky., the H. W. Johns-Manville Co. (100 William St., New York) has found it necessary to move its Louisville office from the Lincoln Savings Bank Building to 205 Paul Jones Building, where it will have larger quarters. J. R. Chowning will be in charge of the new office.

The Leavitt Machine Co., Orange, Mass., has established agencies for the sale of the Dexter valve reseating machine, in Argentine, Brazil, Peru, Chile and other South American centers. The navy departments of Brazil, Argentine and Chile have adopted the Dexter machine and have equipped every ship and naval station with them.

The Lytton Manufacturing Corporation, 1159 Hudson Terminal Building, New York, has appointed L. J. Barthelemy, San Juan, Porto Rico, agent for Porto Rico and the Danish West Indies, and Robert S. Mayer, 931 Garfield Building, Cleveland, Ohio, agent for the State of Ohio.

ENGINEERS WANTED

Under this head are published, without charge, advertisements of actual vacancies in power plants for operating engineers and assistant engineers. For the guidance of applicants for advertised positions, the advertisements must contain particulars to show the class of service demanded and the wages paid. Employers who desire to advertise under this head are requested to write for a blank form of application.

WANT chief engineer; three Harrisburg engines, 400 hp., condenser; one 1500-kw. a.c. low pressure, Allis-Chalmers turbine; three air compressors; plant good condition; work twelve hours day; alternate weeks, night; wages $3.50 per day. Follansbee Brothers Co., Follansbee, W. Va.

ENGINEER for small plant furnishing light, heat and power for institution; plant is new and consists of two 75-hp. boilers, two 15-kw. direct-current, 110-volt turbine generators; wages $60 month and living; wife of married man could also find employment in the institution. Box 585, Power.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About five words make a line.

SALESMAN — Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," Power.

AGENTS for first-class steam specialty in use throughout United States. Address C. S. Wood, 410 S. 15th St., Philadelphia, Penn.

THE VULCAN SOOT CLEANER offers an exceptional opportunity for power specialty salesman Address G. L. Simonds & Co., 802 Steinway Bldg., Chicago, Ill.

REPRESENTATIVES to handle boiler specialties in Philadelphia, Baltimore, Tennessee, Cincinnati, Cleveland, on liberal commission basis; don't reply unless you mean business. Box 586, Power.

PUMPING machinery salesman, a thoroughly competent man to travel principally in southern territory; responses will be considered in confidence if desired. Address, with full information, the John H. McGowan Co., Cincinnati, Ohio.

MANUFACTURERS' AGENTS to handle thoroughly guaranteed steam specialties; feed water heaters, steam and oil separators, traps and exhaust pipe heads; not necessary to represent entire line if interested in only part of it; our specialties are well advertised and of good reputation. Box 569, Power.

SALESMEN WANTED in cities and towns where we are not represented; men handling steam and power plant specialties, or engineers acting as sales agents preferred; straight commission proposition; we manufacture a patented pump valve superior to any other on the market. Address, with particulars regarding lines you are handling, territory desired, etc., the Pump Valve Co., Box 579, Power.

AN OPPORTUNITY is offered to the right man with engineering training or experience, to obtain an interest in an incorporated engineering company in New York City, to take the place of a retiring officer; only a small investment of $3,000 is required, for which stock will be issued and salary paid for services; the company is doing an active consulting and contracting business, also controls valuable patents. Address Box 582, Power.

SITUATIONS WANTED

Advertisements under this head are inserted for 25 cents per line. About five words make a line.

GRADUATE mechanical engineer, expert on power transmission machinery, etc., desires executive position, with partnership. Address Box 580, Power.

CHIEF ENGINEER and master mechanic wants position as engineer or master mechanic in electric light power, woolen, cotton or paper mill; first-class Massachusetts license. Box 578, Power.

ENGINEER or superintendent of small electric power plant; eight years' experience, producer gas, oil or steam; employed at present, but desire change; good reasons; married, sober and capable of rebuilding plant if necessary; state salary. Address Box 581, Power.

MISCELLANEOUS

Advertisements under this head are inserted for 25 cents per line. About five words make a line.

PATENTS SECURED—C. L. Parker, Patents, 904 G St., Washington, D. C.

WANTED—Second-hand Corliss engine, 300 hp., two horizontal tubular boilers, 150 to 200 hp. each; give particulars. Box 583, Power.

PATENTS—Herbert Jenner, patent attorney and mechanical expert, 608 F St., Washington, D. C. I make a free search and report if patent can be had and the exact cost.

ENINEERS AND FIREMEN—Send 10 cents in stamps for a 40-page pamphlet containing a list of questions asked by an examining board of engineers. Stromberg Publishing Co., 2703 Cass Avenue, St. Louis, Mo.

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write today. C. P. Monash, 1417 W. Jackson Blvd., Chicago, Ill.

BUSINESS OPPORTUNITIES—A company owning a power-plant specialty desires fifteen to twenty thousand dollars working capital; a very attractive offer can be made to the parties furnishing the funds; full investigation invited. Address Box 584, Power.

FOR SALE

Advertisements under this head are inserted for 25 cents per line. About five words make a line.

FOR SALE—One new 300-ton electrically-tilted hot-metal mixer of latest design. Address Box 572, Power.

FOR SALE—Five Corliss vertical water leg, and sixteen Manning vertical type boilers. J. & P. Coats, Ltd., Pawtucket, R. I.

8x10 SKINNER ENGINE, direct connected to 30-kilowatt generator, and 8x10 Allfree engine, direct connected to 20-kilowatt generator . Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

LATEST MODEL, heavy duty, 18x42 Brown engine, installed 1904; no reasonable offer refused; this engine was operated by builders' engineer; for sale account of removal; splendid equipment, oil guards, lubricators, metallic packing. Box 575, Power.

ONE PAIR of Harris Corliss engines, girder frame, approximately 300 hp. diameter of cylinder, 16 in.; length of stroke, 48 in.; diameter of flywheel, 14 ft.; width of wheel, 2 ft. 6 in.; revolutions per minute, 54; engines can be seen at the factory of the Salt's Textile Mfg. Co., Bridgeport, Conn.

ONE 100-HP. Smith type "E" suction anthracite gas producer, and one Alberger horizontal tandem gas engine with Rites governor, belt type, with equipment of accessories; used about six months; reason for selling: have sold plant and machinery is not in use. Address Room 1102, 37 Wall St., New York.

THREE 150-hp. Manning boilers, no brick work required, 125 lb. pressure; price, $400 to $600 each; one 14-26x18-in. Harrisburg cross compound engine; splendid condition, $850; 800-hp. National feed water heater, $250; induced draft outfit with stack, suitable for 400 to 1000 hp.; price, $300. J. F. Foster, 166 Devonshire St., Boston, Mass.

ONE GENERAL ELECTRIC direct current generator, type A, 4 pole, 45 kilowatt, No. 925, 360 amperes, 850 r.p.m., 110 volt, no load; 115 volt, full load; three horizontal return tubular boilers, makers, Bigelow Co., New Haven, Conn., 20 feet long, 72 inches in diameter, 94 tubes 3½ inches diameter; two horizontal return tubular boilers, makers, Bridgeport Boiler Works, Bridgeport, Conn., 20 feet long, 72 inches diameter, 94 tubes, 3½ inches diameter; one horizontal return tubular boiler, maker, Pacific Iron Works, Bridgeport, Conn., 17 feet long, 66 inches diameter, 68 tubes, 4-inch diameter. All in good condition, 100-lb. pressure allowed on the boilers by the Boiler Insurance Co., at time of removal. Box 564, Power.

SALE of old material at the Naval Academy, Annapolis, Md. There will be sold at the Naval Academy, Annapolis, Md., the old power plant belonging to the Navy and condemned as unfit for use therein, consisting of Corliss and other engines, Lundell dynamos, panels and switches, Worthington and Woodward pumps, Aultman-Taylor boilers, etc. The sale will be for cash to the highest bidder, by sealed proposals to be opened at 12 o'clock noon, February 19, 1912. Schedules containing form of proposals and terms of sale can be obtained upon application to the General Storekeeper, Naval Academy, Annapolis, Md. BEEKMAN WINTHROP, Assistant Secretary of the Navy.

Condensed Steam For Boiler Feed Should Be Free From Grease

Else you'll have all kinds of trouble.

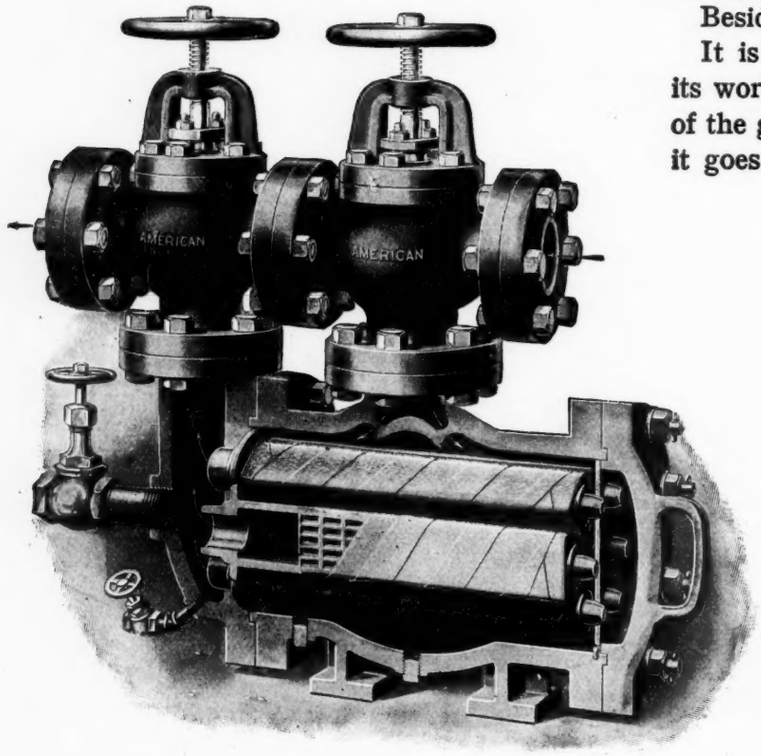
For instance, bagging.

The grease sticks to the tubes and sheet, gets hard, forms a non-conductive crust, and the result—bagging.

And the bagging means repairs, means loss in steaming capacity, and danger of accident.

Prevent bagging and its accompanying evils by making absolutely sure that no grease gets into the boiler with the feed water—

For which purpose no more efficient device is made than



The American H_2O Grease Extracting Feed Water Filter

This is a simply constructed, compact filtering device; the parts are all easy to get at.

It has a filtering surface equal to 320 times the area of the feed pipe, due to the ingenious radial design of the cages.

It is strong, takes up little room, is easy to clean, and cheap to maintain.

Besides, its first cost is moderate.

It is absolutely reliable in operation, doing its work as it should be done, extracting all of the grease from the condensed steam before it goes into the boiler.

Ask For The Pocket Edition Of The American Catalog

Every Engineer should have this catalog on file. It not only describes the device herewith illustrated but also goes into the full story of the complete line of American Quality Power Plant Products. This Pocket Edition will cost you nothing. It is a book worth having and we want you to send for a copy. Write today—the coupon brings it.

SIGN AND MAIL COUPON

American Steam Gauge & Valve Mfg. Co.
Boston, Mass. 2-6-12

Send me your Pocket Edition Catalog

Name. . . . . .

Address. . . . . .

American Steam Gauge & Valve Mfg. Co.

Boston, Mass.

Sales Offices in New York, Chicago, San Francisco, Pittsburg, Atlanta, Montreal

THE BEST HOUSES EVERYWHERE SELL OUR PRODUCTS